THE NEW FIELD OF PSYCHOLOGY

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The Psychological Functions and Their Government

BY

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PREFACE

The reader who is familiar with the author's *Field of Psychology* will discover in the present work a radical change in the general envisagement of the subject. In the pages which follow the appeal to 'mental' forms of existence is wanting. Mental processes, states, and forces are not assumed, either as parts of the organism or as agents responsible for its activities. The living and active body is observed, instead, in two general ways; the one way revealing its *physiological functions,* the other its *psychological functions.* The partition between these types of function is made upon the basis of a natural difference in the method of treatment and in the training and outlook of physiologist and psychologist, not upon any substantial division of the organism into a physical part and a psychical part. The psychological functions are here to be distinguished and described, the bodily resources underlying them to be sought out (so far as the present limitations of anatomy and physiology will permit), and the nature of their initiation, government, and control set forth.

As fundamental a concept as function is the concept of government. No active system maintains itself without guidance and control. Individual parts and members have to be coördinated and the whole system regulated with respect both to its own functions and to its outside relations. Machines are managed and maintained by mechanical devices for regulation, and in public life we recognize the principle of government through social and political agencies and in the equilibrating effects of custom and morals. The human organism just as much demands control. Physiologists have of late made

notable progress in the discovery of the means and the principles of government for their own bodily processes, while psychologists have always assumed that forces within or forces without have kept man active and held him in regulation. Some principle of government is implicit in every kind and brand of psychology. Instead of taking a doctrinal stand upon any one of these theoretical proposals, however, the present work seeks directly to discover behind the actual operations of man all those agencies which initiate, regulate, and control conduct and accomplishment.

Since function—taken in the present sense—always implies issue and output, the psychologist has also to make the same kind of use of functional products (inferring backward from product to process) as the physiologist and the historical geologist resort to. Every function has its issue. Digesting turns out nutritive and waste substances; breathing deposits oxygen in the blood; the processes of upheaval and drift disturb and channel the land and leave silt in the rivers; the whirling cylinders of the printing-press make the daily paper, and so on and on. In the same way, languages, histories, arts, beliefs, and rules of conduct are products which issue from the psychological functions. In other contexts, we study all these things for their own sake; but the psychologist also finds them as significant for the operations whence they have issued as does the physiologist find gastric juice, nutrient products, and oxygenated blood. So too does the geologist examine rock stratum and drift that he may the better understand the processes of upheaval and transportation which brought them into place. Product enlightens process. Beliefs arrived at, objects perceived, topics understood, and languages created all help us to grasp the living and active functions through which these things were produced.

In insisting upon a functional unity in man, the older book mitigated those prevailing beliefs which divide the organism

into two irreconcilable parts. The attempt failed, however, to avoid the intermixture of magical with natural causes, and it failed also to relieve psychology once and for all of the monstrous 'mind-body problem.' By regarding the integrated body as the complete existential structure of the organism and by confining its primary description to the psychological functions of the body, the present book considerably simplifies its task. It also seems to find that this direct description of functions, their conditions, government, and products, supplies a natural and adequate basis for psychological growth and development, as well as for the social aspects of man's activities, and for all the defects and disorders of a psychological kind.

The doctrine of behaviorism once proposed to clarify and to simplify the psychologist's task by striking the term 'consciousness' from its phraseology and by declaring that all psychological activities were 'responses to stimuli.' In thus reverting to a precritical view of the casual relation, this doctrine assumed that the activities in question were always the effects of environmental forces. This assumption ignored the partial independence of the organic system, with its own powers of initiation, direction, and control, and also the actualities of daily experience, where man plainly perceives objects and occurrences, remembers his past, understands speech, observes and criticizes his fellows, bears malice, and is active in many similar ways, quite as factually as he is when contracting muscles, digesting food, and bearing oxygen to the tissues of the body. It is now clear that these actualities were overlooked in the behaviorist's zeal to destroy the implications of 'introspection,' a term which he had never learned to use with success. But today everyone realizes that the dropping of 'mind,' 'consciousness,' and 'introspection' from the vocabulary of the psychologist will no more annul the facts of remembering, hating, resolving, understanding, and the rest, than the rejec-

tion of 'vital spirits' and of the cardinal 'humors' has done away with the physiological operations of breathing and of glandular tempering.

To escape the inevitable limitations of his simple logic of a causal stimulus and response, the behaviorist either joined the laboratory of the physiologist of muscle and nerve or else he so extended 'stimulus' as to make it cover all antecedents of behavior, of whatever kind, with a correspondingly generous use of 'response.' The terms have now become little more than a verbal convenience under the common habit of polarizing all observed occurrences of nature into cause-and-effect; but they do still tend, on occasion, to make men satisfied with a superficial description of psychological facts, a description which overlooks the character and the variety of those functional performances with which the physiologist is wholly unprepared to cope. Behavioristic principles and methods have found their most natural application in certain problems of human and animal performance where the control of the environment leads to obvious changes in behavior. Learning and training exercises with children and with non-human animals have been most conspicuous, for here the setting of conditions in the maze or puzzle-box, the training field, and the school have led to a modification of 'responses' which has suggested useful methods of teaching and has sometimes thrown light upon neural and other physiological functions. To the problems of remembering, imagining, comprehending, observing, and thinking, and to the subtler forms of learning, action, and emotion, the behavioristic formula of stimulus and response is ill adapted.

A natural counterblast to the more extreme types of behaviorism, where the unconscious environment is the sole determining cause, is psychoanalysis where the unconscious soul is the dynamic and directive agent. By a return to the ancient belief in a triune being, psychoanalysis has substituted

for psychology a hypothetical and romantic account of the human organism as compounded of body, consciousness, and the unconscious, sanctioning its beliefs by a theory of healing and a practice of professional ministration which are based upon this trinitarian conception of man. Here magical forces and spirits, long ago driven from physics and biology, are reinstated as prime movers in human conduct. These are the shallows of 'depth psychology.'

From behaviorism we have learned, to be sure, the virtues of a factual approach without obscuring concepts and superfluous categories. From psychoanalysis, on the other side, we may well extract a useful view of life as cumulative and gradual and of the human course from beginning to end as biographical and individual, and therefore as constantly backward-referring. Adopting what is valuable in each of these doctrines, but rejecting their non-psychological forces and prime movers, we should be prepared to make a more direct and a more critical approach than either has made to those functional performances of the organism which supply the immediate and obvious materials for a psychological study of man.

Any book which is ambitious to serve in class and lecture under formal instruction has to pay some regard to the correlative processes of *teaching and learning*. The writer finds himself among those who succeed but indifferently in producing books which instruct the academic novice from the page alone. Many texts read best under the guidance of the well-primed instructor, the instructor with training and information which permit him to use in his teaching the sources from which the book itself has been drawn. All serious works imbedded in a large body of factual material demand either a prepared reader or a human agency for fertilizing the text from the sources beneath.

Not many undergraduate students in our colleges and universities are prepared to bring to a new subject the interest, the accessory knowledge, and the training to permit them to look beneath the surface of lectures and text and really to enter the living and changing subject which they seek to comprehend. Most of us have, therefore, to depend upon the competent instructor. But over the instructor the author exercises at best a remote control. To make this control effective many devices may be resorted to. The best device is undoubtedly clear, competent, and well-integrated exposition of fact and principle, a device which few authors command. Another means is the induction of the lecturer, the tutor, and the teacher into the heart of the subject to be expounded and clarified. Under one form of this induction, sources, accessory studies, and serious discussions of the topics are added. This form here appears in supplementary sections following the text. The student may well assume that all of this supplementary material is familiar to the teacher. A curse of teaching is the instructor who keeps only a chapter ahead of his class, taking advantage of his office and his age to hide his insufficient knowledge and scanty preparation. The competent instructor knows both the depths of his subject and the abilities of his students, adding to the bare text, by way of supplementary reading, or by exposition, new illustration, and explanatory principle, to be derived both from the teacher's own store of knowledge and from the discussions and references provided by the author. The teacher who tries to instruct from the surface of the text is a blind leader of the capable and the indifferent, as well as of the groping, student.

On the side of clarity and connected sequence, more is required when the reader is a novice in the subject expounded than a mere accumulation of facts. The sophisticated reader supplies his own context as he reads; but the novice cannot. To prepare against the needs of the latter, the instructor must

then run on well in advance, clothing for him the bare, puzzling, and difficult statements from his own stores. To this end the teacher is aided by an ample list of men and subjects, which attempts to lay before the reader all the important materials upon a given subject or topic contained in the entire text. Such a thoughtful collection or reasoned catalogue, presented in the index or otherwise, the instructor will do well to use himself and to bring as a first-aid to the student.

Without the help of departmental colleagues the present book would have been far more defective than it actually is. For several terms Professor John G. Jenkins, who has directed the elementary instruction at Cornell University, has cheerfully used in various stages of preparation the materials here presented. Practically every paragraph in the book has profited by conference with Professor Jenkins and the junior members of the staff engaged with him in instruction. Besides accuracy of statement and clarity of phrase, the suggestions and criticisms from this generous group bear also upon the sequence and consistency of subjects and chapters and upon the general organization of the book. This assistance has incurred a heavy debt which the author acknowledges but cannot discharge.

By his wise suggestions and by a critical and scholarly judgment, Dr. S. Feldman has clarified many difficult and disputable points in the exposition, and in a careful reading and revision of the proof-sheets Professor Anna Mathiesen, of Goucher College, has given the entire work the benefit of her thorough and fundamental knowledge of the wide field of psychology. The labors of composition and of publication have been remarkably eased and facilitated by the dexterous help of Miss Margaret Ballou Erb. To all those whose writings, teachings, and advice stand behind the making of any expository book, it is impossible to make so much as a formal acknowledgment. Although the author seldom knows the precise aid

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CHAPTER I

INTRODUCTION

Psychology and Life

Many profess a deep and spontaneous interest in psychology because, as they explain, psychology directly touches human life. It touches the personal activities of the individual whether at play, in business, in love, in disorder, or in the maintenance of family and social relations. At the very springs of life—so runs the explanation—stand hope and despair, fear and anxiety, struggle and success, the satisfaction of aching desire, and the rich and varied coloring of conflict, resolution, and triumph; all personal concerns which seem to call for clarification by the psychologist. To be sure, some of the biological subjects also treat of human life, of family heritage, and of the unfolding of the individual; and certain branches of chemistry touch upon details of bodily toxins in disease and of dietetic ill-being; but psychology appears to bear upon life and upon the homely affairs of men in a much more general, intimate, and interesting way.

Now since our subject is oftener approached from this personal direction than by way of the fields of learning, it is of great importance that the relations between psychology and the active process of private and social living should be anticipated in a clear and definite manner. We shall scarcely set out upon a straight and unambiguous course, therefore, without distinguishing certain fundamental ways in which all men at all times regard themselves and the objects of na-

ture, ways which bear upon the personal and also upon the psychological approach to human life.

Three Fundamental Attitudes

The simplest way to distinguish the point of view of the psychologist from the personal view of everyday tradition is to observe that human beings are so constituted that they automatically assume toward the world in which they live at least three unlike and conflicting attitudes. These are the attitudes of knowledge, appreciation, and use. When a person inquisitively examines a new kind of engine or typewriter, puzzles out the meaning of a knotty sentence in a Latin text, follows a lecture in chemistry, or reads references in history, he assumes *the attitude of knowing.* All serious inquiries after knowledge imply this attitude.

Again, the concert, the opera, the ball game, the delights of friendship, the exhilaration of vigorous employment, the regard for human endeavor and human accomplishment, and the condemnation of wrong-doing, all imply the second attitude, *the attitude of appreciation.* When we appreciate, we enjoy, we judge, we approve, we condemn; in brief, we value.

Finally, man's employment of the world and of its opportunities involves *the attitude of use.* Tools and instruments are, as a rule, regarded under the attitude of use. They are means to the accomplishment of our ends. The mineral stores of the world, the mines of coal and copper, of gold and silver, we generally regard in an utilitarian way. Business and commerce, the demands of war, and the conquest of a new land, encourage men to assume the attitude of utility in order that they may accomplish their desires and command both nature and the fortunes of their fellows.

Toward many of the affairs of life and toward most of the world's objects we assume at different times and for various purposes all of these three major attitudes. We *know* the

animal as a representative of such or such a zoölogical group, we value and *appreciate* it as a pet or companion, and we *use* it as a burden-bearer and for food. The soil we study; the landscape we enjoy; and the land we compel to yield an income. The heavens themselves furnish the astronomer with materials for study and the mariner with useful points of reference, as well as all of us with the loftiest objects that stir the imagination.

Every critical period in the world's history lays its own peculiar emphasis upon one or another of the attitudes. The judgment which the historian passes upon peoples, times, and civilizations rests in large measure upon the exaggeration or the neglect of value, utility, or knowledge. The period of the Renaissance in Europe is famous for its quickened spirit of appreciation. Italy "kindled at the core" and the northern countries awoke in turn to a new valuation of art, letters, and life. Men censure decadent Rome for its bad sense of values when opulence led to a neglect of the utilitarian and inquisitive attitudes that Rome might with great license enjoy the spoils of its conquests. The last century was an era of inquiry and of the application of the sciences to industry. The physical sciences advanced in decades farther than they had in whole preceding centuries. Then invention and discovery created new products and new methods of production. Industry developed, utility was exalted, and 'efficiency' tended to become an end in itself. So declined the attitude of appreciation before the ideals and the conveniences of utility.

All men, then, seek to know, to appreciate, and to use. No one of the three attitudes is to be set above the others, as no one of them can properly take the place of the others. The normal course of life includes the appropriate assumption of each in its proper place. The sentimentalist is a person who abuses his appreciative attitude, adopting it upon occasions when he should either know or use. The man who is en-

grossed in business is tempted to neglect human and artistic values and to underrate learning. The pursuit of knowledge unrelieved by appreciation makes the pedant. The educated person, like Aristotle's large-minded man, is the well-balanced individual who gives to each of the demands of human life its due—who understands when knowledge is required, who appreciates when judgments of worth, whether æsthetic, moral, economic, social, or religious, are in place, and who uses the goods of the world with a proper regard for their values and with an intelligent conception of their nature.

Now the sciences are simply the result of man's most steady and most persistent attempt to compass the world in a coherent and impersonal way by the fixed assumption of the attitude of knowing. They seek, each in its own field, to describe, to understand, and to explain. Psychology belongs to this group. It seeks to describe and to understand certain activities or performances of the organism. The novice, then, who seeks an introduction to the subject will find his path beset with difficulties so long as he insists upon carrying over to his serious studies the distracting mass of bias and misconception which has for centuries accumulated under the attitudes of use and appreciation, and which ministers, outside of psychology, to the layman's interest in things related to himself. The utilitarian view is practical in the narrow sense of employment without knowledge; the appreciative view is the personal view of possession and of emotional regard. In his hours devoted to serious study the student soon learns to discard them both and to direct an open and unbiased inquiry toward the sober facts which fall within the domain of the psychologist. There is no choice. The *attitude of knowing* must be steadily and consistently preserved.

To be sure, either the professional psychologist or the student may easily return—once the facts and principles have been mastered in a detached and coherent manner—to any

of the forms of application in which orderly knowledge is used to clarify and to explain the private and personal problems and issues of life. But only confusion will follow the attempt to serve two divergent interests and to maintain two distinct points of view at one and the same time while the individual is making his first serious approach to the field of psychology.

The Approach to Psychology

Our common experiences are continually suggesting both the sciences of matter and energy and the sciences of life; but just as much do they constantly hint at things psychological in the homely events of everyday. When you have ridden at the wheel of a motor car you must have observed a connection between the speed of the car and your thoughts and feelings. The exhilaration of a crisp morning and of a free conscience is likely to be reflected in an open throttle and a contempt for curves; while baffled thinking and uncertain plans bring the car down to the pace of a snail. Decision, resolve, high moods, and firm intent tell in the one direction; indecision, doubt, and depression in the other. The same kind of hint of 'something psychological' is given with the violent expression of feeling in the grandstand over an unpopular decision, or with a quiet exhibition of sustained fortitude in crushing sorrow. The dentist's office is painfully alive with psychological suggestiveness; the intimate roar and crunch of the drill, the sharp stab of the probe, the curious withdrawal of sights and sounds under the anaesthetic, and the gradual 'return to consciousness.'

But less thrilling and impressive occasions have just as much their obvious psychological aspects. An electric sign flashes past at night and leaves a greenish ghost or after color. You give up the quest for a forgotten name and suddenly find yourself pronouncing it without the least effort; you realize

as you walk that a melody or a bit of dance music has been 'running through your head'; or you learn to devote yourself to study in spite of noise and distraction. You note the lure of the brilliantly colored advertisement on the boards, the blind fury of the riotous mob, the ease of right-hand writing as compared with the awkward attempts with the left hand, the tongue's exaggeration of the size of a dental cavity, the shifting temper of a nation under the fortunes of war, the play of animals, and the short-cuts of genius. Everywhere in daily experience are hints that we move as constantly and as naturally in a psychological realm as within a physical order.

Out of such stuff, then, exposed in its raw state, psychology collects and selects its materials. But the materials must be refined. Merely to note such experiences as the foregoing, even though they be our very own, will no more make a psychologist than traffic in eggs will prepare the eager student for embryology.

We must plainly mark the distinction between intimate acquaintance and scientific knowledge. Were intimate acquaintance a substitute for systematic and orderly understanding, we might look for our most famous botanists in tropical jungles, for anatomists in the great meat-packing concerns, and for psychologists among the crowded tenements. More than a mass of material taken in the gross is required. Detachment is required, training is required, and so are appropriate means for submitting the raw material to the methodical refinements of the sciences.

It is not by chance then, that psychology develops, as physics, anatomy and embryology develop, in the laboratory and in the study. For here distracting interests and practical considerations drop away; the material is simplified, sorted, set into its proper context, and at last filed with other records of the sciences. The after color from the electric sign, for example, is here reproduced under the controlled conditions

of experiment, repeated and varied at will, and compared with other like phenomena. It then takes its place in the psychology of vision. So also the striking advertisement is withdrawn from the street to the laboratory, where it suggests a problem in attentive perceiving. In the same way, the topic of insanity falls under the treatment of the abnormal; idiocy and genius become matters for research upon capability; the orator and his audience are transmuted into problems upon the social integration of men; the tune-in-the-head turns out to be a typical bit of auditory imagining; right-hand writing is made a study in the habituation of function, and grief takes its place among the emotions.

We see, then, that psychological materials lie all about us in our life of everyday; but we see also that these materials are not really incorporated into psychology until they are regarded by the trained observer, withdrawn to the laboratory for more favorable conditions of study, and passed through the alembic of the science.

Now we go on to consider how the novice in the subject must use his meager store of unsorted and unrelated fragments in order to attain the point of view and the orderly knowledge of the psychologist.

The Rejection of Mental Powers

If you will reflect upon your previous use of the words *mind, mental,* and *psychological,* in connection with your own experiences, you will observe that the occasions have related, as a rule, to personal performance and attainment. You will discover that 'mind' has appeared as an effective instrument designed to obtain some end or result. Thus we all seem to employ our minds, as we say, in reading books and street signs, in deciding how to spend the vacation, in trying to understand difficult lectures and textbooks, in remembering forgotten names, in finding our way in the dark, and in

holding ourselves steady under failure and discouragement. So, too, in discussing the defects and gifts of others we speak of the enfeeblement of mind, of the great mental resources of the talented, and of differences of mental ability and mental accomplishment. We take for granted the 'strength of thought' and the 'force of will.' Always an *acting* mind; always a mind at work; always a performance or accomplishment which enters into the affairs of life, bending events, with greater or less effectiveness, toward some desired end.

This is a perfectly natural and a perfectly inevitable first and informal view. In a similar way do we know trees as active, growing, fruit-bearing, and shade-producing objects before we begin to gather our botanical knowledge. So do we have a fairly wide and varied knowledge of animals, of their habits, uses, and activities, before we enter upon our zoological studies; and we may be familiar with the lathe, the sewing machine, or the motor car, so far as functions and operations go, without mastering the subject of mechanics or attaining to an exact knowledge of materials or of machine-design. In general, let it be said that our early pre-scientific acquaintance with ourselves, as well as with the common things about us in nature and in manufacture, is chiefly an acquaintance with gross uses and ends, and is not an exact and well-ordered comprehension of matters psychological.

This difference between mere acquaintance, no matter how intimate and searching, and coherent knowledge we must not overlook, then, as we pass the threshold of psychology. The distinction is of special significance at the beginning because 'mind' first presents itself to us, outside psychology, as a peculiar, personal possession; as something which each one of us must perforce know and appreciate very much better than any mere outsider can. Besides this personal bias regarding 'our' minds we all commonly employ such phrases as 'paying attention,' 'exerting our wills,' 'controlling our emo-

tions,' 'searching our memories,' and 'directing our thoughts'—phrases which have a psychological sound and which seem to imply a fairly high sophistication regarding ourselves. As a matter of fact, they usually imply no more knowledge of psychology than our glib references to a 'sluggish liver,' a 'touch of indigestion,' or a 'twinge of rheumatism' imply accurate knowledge of the physiological disturbances which afflict our bodily interiors.

Common Sources of Confusion

Now there arises from these sources an overpowering temptation to carry over into psychology old conceptions and opinions. Regarded as knowledge these conceptions and opinions and these terms and phrases are spurious; they are not made of the true coinage of psychology. If we take them at their face value, they offer a decided hindrance to our entrance into serious study. It is like taking a wrong start at golf or making a bad beginning in music. In describing the adventures of Gargantua, when that robust student went up to Paris to study at the University, Rabelais refers to a music master, one Timotheus, who was accustomed to exact a double fee of those students who came to him from other masters, observing that, in their case, at least half of his time and pains was spent in removing the effects of bad antecedent instruction. The case of Timotheus is appreciated by every psychologist who has helped the novice through his first introductory weeks of study. It will be appreciated by the beginner, too, as he discovers how many wrong impressions interfere with his intent to master a new subject.

Like many other opinions and preconceptions which we acquire uncritically and without reflection, these troublesome assumptions about the province of psychology will be abandoned only when we have come to realize the source as well as the force of our makeshift and spurious knowledge, and

also when we see as clearly as we can the new direction which we are to take. If we are therefore to follow the example of Timotheus far enough to insist upon the giving up of old prejudices and the relinquishment of inappropriate points of view, we must first look behind and discover the origin of our errors. We shall thereupon find that there are at least three chief sources of confusion. The first of them lies in the important part that alleged magical causes, as distinguished from natural causes, have played in forming man's beliefs about himself and in his powers. Throughout human history mind has been the abode of occult and telepathic forms of divination and of clairvoyant insight into the mysteries of life. In the second place, philosophy—which long overshadowed psychology—laid an emphasis upon the distinctions of subject and object, of intellect and will, and dwelt upon the nature of the soul at the expense of more factual problems of a psychological character. Along with philosophy, theoretical biology, with its vagaries about a directive, adaptive and controlling mind, has likewise confused the issues of psychology. In the third place, language itself—the servant of the sciences—has suggested, by substituting picturesque words and phrases for actual processes and functions, that mind may be a thing alert, sluggish, lost, unbalanced or concentrated. [1] *

Psychology Treats of Certain Activities of the Living Organism

So much by way of approach! It is unfortunate that an 'approach' to our subject is necessary. To enter straightway and survey the actual field would be much pleasanter both for reader and writer. But a clear survey demands clear vision; the 'emmetropic' or perfectly-tuned eye, as the refracting optician calls it. So easy it is, however, to confuse one fundamental

* Bracketed numbers in the text refer to sections in the Supplement, where many topics receive further treatment. See pages 353-427.

attitude with another, to distort plain fact by ardent wish or inherent prejudice, and to substitute folk-belief for the disinterested search for truth that a preliminary clearing-away cannot be escaped. In the last analysis, it cannot be avoided because men come to psychology with a fixed conviction that they own and possess a mind active and powerful, a mental agent that thinks, feels, knows, decides, and generally governs or misgoverns behavior and conduct. As we can see, this belief is vague, inconsistent, and more than half magical. While the long history of man has made it evident that a belief of this sort is convenient and effective in the practical affairs of everyday living, you will readily understand that it serves no better as a foundation for psychology than would the corresponding belief in a magical and wilful 'Nature' serve as a foundation for physics and biology. [2]

When we turn, then, our emmetropic eyes to the actual field of psychology, we observe there no resident mind, no mental agent, no mental governor, and no hidden forces of thought, desire, and will. That is easily and briefly said; but you may find that you will have at times actively and laboriously to exorcise old spirits and forces, which are more firmly ingrained in your beliefs and attitudes than you realize at this moment.

But what are we to substitute for these old and comfortable notions? We shall substitute only what we actually find, forsaking whatever has to be supported by traditional beliefs, by men's desire for personal power and rule, and by philosophical or theological reflection and conceit.

In the first place, it will require no persuasion to make you observe that you are, as a matter of hard fact, looking at this page and understanding at least a part of what is here related. You may also be engaged in thinking out the matters here proposed. In plain terms, your organism is *perceiving, comprehending* and *thinking-out* or *elaborating*. We shall speak

of these activities as *functions.* They are functions in the very same sense as a digestive process in the stomach and the aeration of the blood are functions of the organism. It appears also that perceiving involves the eye, the brain, and other bodily structures, and so do comprehending and thinking-out involve various bodily organs and resources just as digesting and aeration do. We shall find it wholly unnecessary to assume that there is also involved another kind of organ, power or agent, which men have called a mind or consciousness. On the other hand, if we were to say that there is nothing going forward in our organisms as we read but the moving of the eyes, of the vocal mechanism, and of the head—as the behaviorist sometimes does,—we should absurdly refuse to observe the plain fact that *we are perceiving, comprehending and thinking.* These are performances of the organism that are just as factually and usefully describable by the psychologist, when he is trained to their observation, as circulation, secretion, and cellular change are describable by the student of blood-flow, gland, or cell. [3]

Physiological and Psychological Functions

Now when we watch the active body at work or at rest we observe that it *does* in a very wide variety of ways. Were you to catalogue all the things which your organism has done since you arose this morning, you would find the list long and exceedingly varied. As you looked it over, you would plainly see that the performances fell naturally into two great kinds, physiological functions and psychological functions. This is not only a natural gross distinction: it is also of great practical convenience because the physiologist finds himself fitted by training and interest to deal with the physiological class of functions and the psychologist with the psychological class. Neither succeeds well when he goes outside his own proper range, unless he has schooled himself to take now the

physiological, and now the psychological, point of view. The physiologist is no more prepared to deal with the functions of perceiving, comprehending, remembering, imagining, and the like, than the psychologist is prepared to deal with the specific functions of the liver and the pancreas.

In order to discover those operations of the living organism which are properly called psychological, it is useful to regard what we loosely call the works of man's hand; *i.e.,* cities and railroads, sown fields and planted wood-lots, automobiles and radios. In a sense these things are literally the product of man's hand, although machines are everywhere being substituted for manual operations. But all these products or works have demanded something which is not revealed by an examination of the hand, or, for that matter, by an examination of the structures of man's entire body. No man could build who did not *perceive* materials, *understand* their preparation, *remember* architectural types, *imagine* new types, and *think out* the difficulties of construction. Man must also *desire* to build, *act* upon his resolve, *feel* the correctness of proportions, *appreciate* blame and applause, and *anticipate* the uses which his fellows will make of his new constructions. The same prerequisites will be found for the other works and accomplishments of man. And when such products as novels and histories, languages and literatures, encyclopedias and sciences, fine arts and music, laws and opinions, are discovered along with material constructions, the very same implication is to be found. For all these works, too, involve and depend upon what we call in the aggregate the *psychological functions* of man. [4]

The Main Varieties of Psychological Function

Our first great embarrassment in the quest of fundamental modes is due to the remarkable versatility of the human organism. Man turns his hand (so to say) to the most widely

diverse performances. Besides supplying those primal wants and necessities which he shares with many other animals, he reads, writes, talks, thinks, plans, constructs, and joins his fellows in hundreds of coöperative projects. How does he accomplish all these things? How many unlike modes and means does he possess and employ? Does he do every different thing in a slightly different way, so that his psychological resources equal in number his accomplishments? It is obvious to all of us that he bends one and the same means to the accomplishment of different ends; and it is just as obvious that he is able to reach one and the same end by the employment of diverse means and agencies.

We begin with the organism, as we actually find it at work, leaving to the physiologist the task of distinguishing and describing such operations as have to do only with chemical and biological processes running their courses in the several organs and organic systems of the body; in heart and blood vessel, in stomach and intestine, in lung and liver, in muscle and gland, in nerve and brain. Many and various are the results of these physiological operations, *e.g.*, blood is formed, aerated, sent hither and thither about the body, and changed in its constitution; food is ingested, reduced to simpler forms, charged with bodily fluids, re-integrated for cellular uses; cells are supplied with new materials, they grow, subdivide and die.

The general economy of these processes is to keep the body integral and living. A great deal of this physiological knowledge is to be turned to psychological uses; but the fundamental problem of psychology is not to watch and report upon this integrating and discarding process of living as supported by the several organs and tissues. It is rather to observe the organism in *apprehending* itself and other objects, in prophetically *carrying out* its own activities, in *setting and resolving* problems, in *divining* the significance of things, in

communicating and *participating* with others of its kind in the affairs of human groups, and in *combining* its beliefs, customs and knowledge into large organized systems. Where the physiological functions constantly fashion and reconstruct the living body, the psychological functions fashion and reconstruct knowledge, conduct, society, and the universal theater of objects, events, desires and values. [5]

We may well expect, from the diverse issues and products of the psychological functions, to find diverse modes. And this expectation will be supported by the vast array of things that we are able, at the close of any day, to report from our working and playing hours. We have seen, listened-to, and proposed; wished, given up, and resolved; remembered, commented-on, and criticized; imagined, puzzled-over, and divined; feared, hoped and dreaded. Activities such as these we could largely extend without exhausting the performances of the day. Fortunately for our functional descriptions, however, our basal functions are few, though curiously combined to meet many occasions and to give the varied and kaleidoscopic coloring which we actually find in our occupations and our diversions.

Let us assume, for the moment, such an organism as our own, which is preserving its integrity, moving about, acquiring and taking in food, water, oxygen, and other necessities, settling accounts with an active and insistent environment, modifying itself as it runs off its life-span, and yet taking into account essential differences between the present occasion, the past, and the future. Assume also that this organism has only its physiological means of doing—its processes of digestion, chemical reconstruction, circulation, secretion, cellular metabolism, excretion of waste, and the like. Now let us ask what psychological performances—given its structure, its necessities, and its organic resources—we might reasonably expect to complete such a creature. [6]

It is obvious, in the first place, that *the means of envisaging the run of things,* present, past, and future, with the distinctions of tense which such an envisagement might imply, would be a natural complement to the physiological equipment. These psychological functions we do actually find as of an *apprehending kind*—namely, perceiving, remembering, and imagining—wherein the organism lays hold of or apprehends objects, states and occurrences. When we come to discuss these functions in future chapters, one of our primary and most exciting problems will be to try to trace out how, given the organism and the theatre of life, the body has managed to create just these actual psychological means of operation. We shall find that the facility has not been acquired in a day. All up and down the long scale of animal forms we shall find hints and adumbrations of such functional accomplishments. There are plenty of animals that can do just a little bit of simple perceiving and no remembering, and some others that are capable of anticipating by a mere flash of imagining what is about to come but without any resources for building up the past by means of a memorial reference. We shall find also that the apprehension by the organism of its own body and of something which it surveys as its own 'self' has been a very great and a very difficult accomplishment, attained in varying degrees and in various forms by the rat, the raccoon, the dog, the monkey, the child, and the human adult.

Just in so far as we can persuade ourselves to face sensibly the facts of animate existence, shall we find that the processes of apprehending our own bodies as well as other physical bodies and of apprehending the panoramic events of nature—past, future, and possible, as well as actual and present—are all natural processes, slowly and laboriously acquired, and just as naturally exercised as are the physiological processes of breathing and digesting.

To be sure, the account which you have heard from your

elders and your teachers has probably implied a picturesque entrance of knowledge through the avenues of sense, a working over and extension of knowledge by 'the mind,' and the creation by 'thought' of mental things called 'ideas.' Such short-cuts through allegory are tempting to all, but they are unsatisfactory to the serious inquirer after actual ways and means of gaining knowledge and of meeting the demands of daily living.

In the second place, the great and varied motor activities of man would seem to suggest *executive functions; i.e.,* the determination of movement, its anticipation, its stages, its outcome, and its results in bodily orientation and in active intercourse with objects. The relevance of such an executive kind of function stands out when we compare human activities with (say) the daily life of the sessile sponge or of the clinging oyster in its rocky bed. Again, the complexities of living for such beings as ourselves are bound to be very great, so we might reasonably look also for a function which would stand for perplexity and conflict. The first of the executive functions we find at hand in the many forms of *action,* through which runs a forward-looking determination, and the second in *emotion,* which is characterized by the predicament and by checks and inadequacies at the difficult turns and the exigencies of life.

Now the apprehending and the executing functions of the organism are basal. Without them our present rôles in the drama of living would be quite impossible. That is not to say that life itself would be impossible. Life goes on perfectly well in the geranium, the oak, the fern, the sponge, the oyster, and the amoeba, though no one of these organisms has the means of perceiving, imagining, acting, or emoving,* any more

* English seems not to have retained a verbal form to correspond to 'emotion' and 'emotive.' We can only revive the obsolete term 'to emove,' which stands to 'emotion' as 'move' to 'motion.'

than it has the means for walking, copulating, or manufacturing blood-sugar. These organisms live, but not according to our complicated modes; and where these functions are very greatly restricted in our own kind, as in the imbecile and the idiot, the creature is quite thrown out of commission, although his fundamental physiological processes are sufficient to keep him going for years with the aid of his more fully equipped fellows and their charitable institutions.

But while these apprehending and executing functions are basal to our primate activities, they do not exhaust our psychological resources. Consider again the physiologically constituted and equipped primate, this time the perceiving, acting, and emoving kind, and ask what additional functions we might reasonably expect to find.

In the first place, notice that life is an on-going and directive process. It takes a course. It proceeds. It uses available energies, but not as the radio-active substances do in a general dissipating way. It ingests, digests, distributes, and eliminates: it oxidizes, transforms, and generates specific energies of heat and motion: it puts out moving members, grasps, contends with, and forces its way: and it produces eggs, undergoes fertilization, and reproduces its like.

In short, the organism is a partially independent and persistent physical system which energetically moves through its life-course in a directive way. It may begin with the fertilized egg and proceeds irreversibly and in a fixed sequence toward birth, infancy, childhood, adulthood, and death. On the psychological side, appropriately appears the functional aptitude of *search,* a mode which is obviously displayed in the human infant soon after birth, and which naturally exemplifies the energetic and directive course of living. When later this *primitive search* is combined with the digestive sequence of feeding, assimilation, and removal of waste, and still later with perceiving and the simpler forms of action, there concordantly appear the

more elementary operations of desiring, longing, anticipating, and attaining. Thereafter and throughout life, the derived and complicated forms of searching play a large part in the psychological economy of the child, the youth, and the adult.

One inevitable outcome at this second level of searching perception and searching action is *inspection,* a scrutinizing alertness which carries the organism well beyond the apprehension of obvious attributes and mere impulsive action to a persistent examination and testing of objects and occurrences. This is the root of observation and exploration. Here the new inspective mode comes to function, a mode which we share with apes, monkeys, some other mammals, and a few of the higher insects (*e.g.,* the ant and the bee), but which is far more effective in man than in any other creature.

Another inevitable issue of apprehending and inspecting is the derived mode of *comprehending* or understanding. Thus do we put together, compare, relate, proceed from observed effect to cause, and otherwise consolidate our knowledge. Again man stands preëminent—though not alone—in a new and derived functional employment, an employment which would be quite inexplicable without the antecedent modes of perceiving, searching, remembering and inspecting.

One further stage in functional acquisition and we reach our human limit. The processes of searching comprehension inevitably turn out problems of a special kind. The water always manages to flow downward through the rocks: but why? Neighbor X obviously distrusts one: but why? The electric wires tingle when the switch is closed: but why? Here is food for thought. Here is the formulation of a sort of problem that can properly be solved only by the use of a new function, the mode of thinking-out-to-solutions, the mode of *elaborative thinking.* Given (1) the problem, (2) the symbolic materials supplied by words, algebraic symbols, and so on, and (3) a kind of anticipative determination, such as the

more deliberative forms of acting have already supplied, we have the rarest and most difficult type of performance in our whole human list, true thinking.

While our list of psychological functions thus reasonably supplied is limited (perceiving, remembering, imagining, acting, emoving, searching, inspecting, comprehending, and elaborating), each one has many variant and intermediate forms and an endless number of ways of combining the functions into twos and threes. Thus they present us with an aspect of living which is as complicated and withal as resourceful as the physiological type of performance is. It is inevitable, therefore, that we shall spend a good part of our introductory studies in an examination of these psychological functions and of their various sub-forms and combinations.

Bodily Support of the Psychological Functions

Since we have forsaken mental faculties and agents, we must turn to the organized and living body to discover the means of support and continuance of our functions. This is as true of the psychological activities as of the physiological. These bodily means are extremely wide and varied. At times the body is engaged generally and at large: at other times some group of organs or some system (*e.g.*, the nervous system) must be scrutinized for the support and control of a specific function. Always, however, our functions presuppose an intact and unmutilated organism. Of course, the loss of a tonsil, an eye, or even of a kidney or a leg, does not subtract any single type or kind of psychological function, and some simpler animals get on very well with much greater bodily losses; but the general notion of intactness of the body-at-large, as opposed to dissected isolation, does hold, and it holds with somewhat greater strictness for the psychologist than in physiology, where piecemeal functioning may be carried to greater lengths, *e.g.*, in the nerve-muscle preparation, the beat-

ing of the excised turtle-heart, and the independent growth in the laboratory of certain embryonic tissues. The difference is, however, only one of degree.

As we examine the several functions, in subsequent chapters, we shall discover that there is scarcely a part or organ of the body which is not sometime and somewhere brought into requisition for perceiving, acting, emoving, comprehending, and the rest. Since we have no 'mind' or 'self' seated advantageously at the top of the brain, we shall not be unduly tempted to make the mistake of confining ourselves to that limited part of the nervous system when we look for our functional supports.

Without anticipating the details of bodily constitution, we may here remark that the nervous structures, the sense organs, and the skeletal muscles form the central part of that support and that these systems bring in, in various ways, glandular, digestive, circulatory, and respiratory apparatus and performances in many precise and appropriate patterns as we are psychologically active from minute to minute and from day to day. Properly to understand these activities, therefore, we shall have to draw upon the knowledge of the anatomist, the physiologist, and even the embryologist and geneticist, for essential information. No activity goes on in a vacuum; always there is the living body supplying the exact and particular ingredients and processes for sustaining the kaleidoscopic operations of living. [7]

The Government of the Psychological Functions

Now no highly organized system simply runs on-and-on by its own inertia. It has to be governed, guided, and controlled. Account has therefore to be taken not only of supporting structures and mechanisms but also of means and principles of regulation and re-direction. While it is sometimes difficult—indeed impossible—to draw a strict line between sup-

ports and governors, the distinction is clear in principle and very useful in practice. We look, then, in the second place, for those means and agents which conduct, control, and actively regulate the organism as its psychological functions proceed. Without such means and agents, living would be chaotic and futile, its orderly advance too much exposed to the factors of chance existing at the moment and to the vast complexities of bodily organization and of the environmental context.

The principle of government and regulation we most readily apply to the political state in the forms of executive, legislative, and judicial control. Here we distinguish forms of government and the various agencies concerned in organizing and conducting the affairs of peoples and nations. The principle is commonly applied also to complex mechanisms and to self-running machines which require the active coördination of parts. The steam engine has its governor; the internal-combustion mechanism its timer, its graduated fuel-feed, its provisions against change of load, and its steering gears; the power-plant adjusts its supply of current to the variations in demand, and the radio receiving-set is tempered to the strength of signals. But when we pass from man-built mechanisms to the greater complications of living systems, we naturally find that far more elaborate and far more refined provisions have to be made for adjusting, controlling, and governing performance and output, whether the performance is physiological or psychological. Thus the problem of government and regulation of function appears as one of major and fundamental importance in psychology as it also appears in physiology.

How, then, are we to discover the sources and the forms of government which provide that, at a certain time and under a certain set of circumstances, the organism shall perceive so-and-so, or remember a given event in the past, or

act in a given way, comprehend a given matter, fall into a fearing emotion, or resolve to carry through such-and-such an act at a future time? The possibilities are actually more complicated than this occasion implies, for it is likely that, at the given time and under the given circumstances, two, three, or even more functional modes will be appropriately combined in a precise way and directed toward a particular end.

We cannot simply say that 'stimuli govern us' because hundreds of stimuli are always raining upon the organism and sometimes not one of them is primarily determining function. We cannot simply say 'environment,' for at times environment is practically ineffective and frequently inconsistent and self-opposing. 'Purpose' is not a universal governor, for often no trace of a purpose is discoverable. And so with 'drives,' 'attention,' 'association,' 'instincts,' and all the other favorite governors set up by men, schools, and doctrines. [8]

Let us look to the living body with its actual history and in its actual context to discover how many and what are the sources and agencies of government, control, and guidance.

The very fact that men have variously proposed all of the means of government just reviewed suggests that government is not simple and not monarchical. Could we believe that man's course is steered by reason, free-will, or the arbitrary decrees of a deity, our problem would vanish. When we ask quite concretely, however, 'why was I just now perceiving, or imagining, or acting in just such-and-such a way and with just this particular outcome?' we are not greatly aided by the assumption that such a general and universal agent is responsible for all our doings.

No; governors and regulations are many and their guidance of function is complicated. We may, however, include most, if not all, of the regulating factors and principles under a few simple and convenient headings. A rough list would stand as follows:

i. Extra-organic governors,
ii. Organic governors, and
iii. Historical governors.

i. In the first kind of government, control and guidance are primarily imposed from without. Although the living body is, as we have observed, a partially independent physical and biological system, maintaining its identity and individual status throughout life and in the face of destructive forces and agencies, its course is variously directed and governed from the outside. This government profoundly affects its psychological modes of activity. Direction comes first through such chemical interchanges as are provided by food, moisture, and the flow of heat and gases. The psychological functions are correspondingly modified by diet, climate, and the quality of the respiratory air. A more instant and effective government is by way of outside energies delivered at the receptors (*e.g.*, light or sound waves), to determine especially perceiving, inspecting, search, and action. Beyond the mere attack at receptors appears a profound guidance by way of moving masses in the great world. A frozen and static environment would have left the organism to a far freer self-determination of its functions, for the changing panorama compels the organism to accordant executive activities and tends to diminish thinking, memory, and imagination.

But beyond the organism lie also human beings and the customary and acceptable modes of conduct. These are added as directive agents to the physical scene. Human beings and human modes govern to an extraordinary degree. Dependence upon and guidance by other individuals, groups, and immanent human modes are too impressive and too multiform to call for extensive comment. Not even the recluse or the shipwrecked mariner escapes this source of control; and for the more active and coöperative member of social groups there is

an unspoken direction imposed upon his behavior from race, people, institutions, community, associates, and family. In every waking hour is the organism instructed, set tasks, hinted-at, reproved, and encouraged by these unformulated precipitates of human opinion and preferred mode and manner. Not only are the functions governed and guided thence; the very objects of apprehension and the subjects of comprehension and thinking are largely provided from this same human source.

ii. Government, as we here conceive it, is always interactive. Objects, energies, and human modes do not simply invade the organism to determine therein direction and control. The organism meets these determinants half-way. Its own state or condition is a co-determinant.

Structure and organic integration are here important. The same external objects and activities differently govern two organisms one of which possesses an elaborated cerebral cortex and the other none, one of which has resources for hearing songs and rhythms in nature and the other none. In those primate creatures which can replace perceptive by memorial apprehension—turning the central nervous system to particular account—a new form of free guidance from within the organism is realized. In general, a high development of the psychological functions implies a relative freedom from outside governors and a corresponding increase in control from within the body. The devices evolved toward this end we shall discover, as we go on to our more detailed study, to be almost innumerable. Self-sufficiency and freedom are here primarily matters of organic guidance and determination.

Again, these inside means are physiological as well as structural. They are well illustrated by neuro-muscular refinements through which most of the psychological functions are both supported and controlled, and also by those vocalizing processes in the mouth and throat through which the sound-

vehicle of thousands of verbal symbols is provided and governed.

A third source of organic guidance is the neural trend. Neural and neuro-muscular patterns are seldom momentary. They leave the body disposed, and a functional disposition implies that a certain subsequent operation has the right of way. Early stages of function therefore tend to determine their own direction and thus to carry on in the face of competition. This advantage we often use when we reinforce the 'good' trends by such verbal and social approvals as "this is right," "this will educate you," and "this is the best way." Thus by transferring the accepted modes of the community to the self-object, under the guise of conscience and duty, the organism once more transfers to organic and internal management what was before directed upon it from the outside.

iii. The historical governors are substitutes for the past. The past being dead still directs. The processes of development and education are, in large measure, a means of guiding the organism by way of residues of earlier function. The past is thus in effective control of the present.

These historical residues are of two sorts, the biological and the biographical. The one carries the racial and familial past, the other the individual career. The first is a heritage from stock, from growth, and from the exercise of physiological function. The second is a heritage from the individual life as it has been socially lived among its kind. The psychoanalysts believe that the biographical past (at least features of it) persists in 'the unconscious' to afflict the disturbed person at a later time in the form of disease and symptom. To doubt such a picturesque form of persistence is not to minimize the great effect upon functional government actually exerted by the historical residues of biographical events.

From these three main sources, then,—external, organic, and

historical—comes government of the psychological functions. Although we can here and there discover one of the sources as major and determining, we must not forget that the organism is one and integral and that in the commonest case a given performance is the fused resultant of all three determining influences. While the human life-course is marked by the successive ripening of the several functions and by the constant application of these functions to new tasks and for new accomplishments, a still more important phase of living is the acquisition of a governed direction and control of performance which will fit the organism for smooth and effective accomplishment under all the necessities of living. Nervous breakdowns, insanities, and human failure at large are, in large measure, the natural end-result of unresolved conflict and of badly integrated government.

Government and Instruction

Within the laboratory the psychologist studies in an experimental and descriptive way the various forms of function and the various means of government and control.

In order that a given function or group of functions may be produced as he directs, he has to determine by his experimental arrangements a given state of the body and a given setting which will initiate under the best conditions the functions to be studied. He therefore makes a primary use of what he terms *instructions*. These are of three kinds, formal, occasional, and self instruction. The formal kind is usually given in words ("Read the nonsense-syllables when they appear here," "Look at this spot and report the color that appears," "Press your finger when the light flashes"). It suggests a specific activity and the general way of carrying it through. Occasional instructions are governing factors from the outside context (the occasion). Thus two nonsense syllables given on a single line tend to be read together; a click

in the apparatus is taken to portend the coming on of the light; or a pressure of the head-rest on the cheek draws the eyes away from the spot where the light is to appear. The self-instruction issues from the observer himself. It may run, "I could well do something much more difficult," "I fear that I shall make a mistake," or " I am growing tired." [9]

Psychological Products

Every function has its issue and outcome. Functional activities are not mere 'idling.' They turn out products. In industry the product appears as output of factory and shop. The printing press turns out papers; the engine supplies energy for power or transportation; the activity of gland produces a characteristic secretion; and the contraction of muscle moves the body, its members, and its tissues.

No less do the psychological functions produce. One of the most obvious products is *knowledge,* an issue of several of the functional modes, operative from early childhood, constantly depositing its stores within the cover of books, and holding its more fluid forms in the lore, beliefs, and sagacity of men. Thousands may simultaneously contribute to this noetic treasury, and each successive generation adds its contribution and makes its characteristic revision. The more coherent divisions are consolidated into philosophy, the sciences, ethics, aesthetics, law, theology, history, mathematics, and so on, divisions which are presented intact in the curriculum of our schools and universities. Various typical combinations of the perceiving, remembering, imagining, emotive, comprehending, and other functional sources appear in literature, in aesthetics, in history, and in the sciences. Thus literature extols the fruits of imagining, aesthetics the valuing issues of emotion, and history those of remembering, while the sciences rest upon a combination of observational inspection and imaginational construction. The languages (at once products and materials of function)

likewise accrue as products only to those organisms which are capable of certain operational activities of a psychological kind.

We must also add to this category the skills, the resolves, the plans, and the social solutions which chiefly come out of the executive group; the abstract, symbolical, and divinatory insights into the nature of things; the entire formal structure of society, and the beliefs, opinions, convictions, rules, and usages which hold men together and make cultural living possible. Where the primary issue of the physiological functions is the sustaining and refashioning of the living body, the psychological functions mainly create and sustain an orderly life among men and in the shifting natural scene, establish values and scales of worth, mould and maintain tradition, initiate and prophetically carry through plans and resolutions, fashion implements for re-fashioning nature, and maintain and extend human knowledge and human understanding.

The entrance to psychology, then, first implies an approach to a good half of all the activities of man, an approach which elects the fixed attitude of knowing and rejects the attitudes of private and romantic appreciation and of immediate utility. Beyond the survey of the psychological functions, the entrance further implies an inquiry into the bodily resources of these activities, a survey of all the means of their government and guidance, and it finally looks toward the characteristic products and issues of those functions which create knowledge, skill and the social order, and which serve to discover—so far as man can—the meaning and significance of human life and of cosmic existence at large. [10]

CHAPTER II

THE APPREHENDING FUNCTIONS

Perceiving we have designated as one of the forms of apprehension. When we say that the organism is apprehending we mean nothing more than that it is active in a manner that apprehends or lays hold of objects, events, scenes, and occurrences. As you now lift your eyes from the book and look across the room, you apprehend the table yonder with books upon it and the rug beneath it. As you look from the window you apprehend the moving line of cars in the street and the smoke curling from the factory chimney. As you listen you apprehend the twelve o'clock whistle, the chimes ringing in the tower, or the train rumbling over the elevated tracks. You may also, under suitable conditions, apprehend the brisk beating of your heart, the quick, straining alternation of your legs in running, the aching stiffness of your neck, the impertinent fly alighting upon your nose, or the cold sleet driving against your cheek. *What* you apprehend is just a functional product, taken in the sense of the last chapter. *The apprehending itself* is a characteristic activity of the organism, one of the commonest and the most easily understood of all. It is identified as one of the psychological, not one of the physiological, functions.

We specify that apprehending is of the *perceiving* kind when we are laying hold of objects, events, and the like, *as present and as going on now.* Thus we distinguish perceptive apprehension from memorial apprehension, as when the table,

moving car, curling smoke, or impertinent fly is represented as fitting into some past scene or as dated at some past time in one's own history. There the organism is *remembering.* The primary difference is a difference of tense; but the body is called upon in two somewhat different ways when it is apprehending as present (*i.e.,* perceiving) and when it is apprehending as past (*i.e.,* remembering). At other times and upon other occasions we also apprehend imaginatively. Then the object or scene is neither seized hold of as present-now nor as present-then but as a part or feature of an anticipated or supposed scene. Thus we imagine the coming of the grocer's wagon as we impatiently await the vegetables for dinner; we imagine the skylark as we read the poetic description of its flight; we imagine bandits at the bank as we hear of last night's robbery.

Upon all these occasions the organism is active in a characteristic way, the way of apprehending. This is a functional mode, and it runs its course in these three related ways, the perceiving way, the remembering way, and the imagining way. First we are to consider the perceptive form of apprehending and after that the other two forms.

PERCEIVING

When you read the words 'perceiving' and 'perception you are almost certain to take as your own first example the apprehension by means of the eye of some spatially fixed and enduring object. That is our common and stock example of perception. It is a perfectly good example; but it should not prevent you from realizing that we also perceive objects and occurrences of many other kinds. You perceive, for example, the exciting dot-dash call over the radio; you perceive the hurried clip-clip, clip-clip as your sleeping car passes over the rail-joints; you perceive the sad and dripping wail of the broad-

casting Romeo; you perceive the terrific impact of the overturned automobile as it careens against a telephone post: you perceive the panting struggle of the locomotive as it labors up the hill: and you perceive the deepening of the red sunset. Wherever and whenever the organism apprehends-as-present, there it perceives. But first we consider the perceptive apprehension of objects taken in the more customary sense. To succeed here we have only to discharge the old magical notion of a mind which sits near the top of the brain and scrutinizes objects as they come, telegraphed in shorthand along the nerves from eye and ear; to discharge that notion and then to observe how perceiving actually goes on and what factors of bodily support and of government are actually involved. [11]

The Perception of Objects

Since 'objects' commonly have their abode somewhere in space and are qualified by such spatial properties as length, size, shape, and the like, we might easily involve ourselves here in the mathematics, or even in the metaphysics, of space. To avoid such a confusion of outside studies with the real psychological problems of space, we have only to consider that the notions of 'tridimensionality', 'mere space', 'the spatial absolute', 'the infinite', and many others of the same order, really belong quite beyond the concrete perception of objects, of their changes, and of their movements.

When we leave the spatial husks and the mathematical notions and abstractions and return to perception and its problems, we find that we have to deal with the present apprehension of objects which are near and far, large and small, broad and narrow, right or left, up or down, and which are definitely placed within the total mechanical world. The spatial peculiarities qualify objects just as much as do their color, their weight, their construction, and the uses to which they are put.

All of these qualifications appear, when viewed from the standpoint of the psychologist, as incidents in, or as products of, the apprehensive functions. We must also remember that, for the actual perception, the spatial qualifications do not stand alone; that the bookcases, for examples, which stand yonder against the opposite wall are not mere long, narrow forms occupying a rectangular space; they are perceived as 'those bookcases filled with books.' If we abstract from this concrete meaning, as psychologists often do, and treat only the geometrical properties of the bookcases, we shall at once incline toward the problems of geometry and away from our psychological task. [12]

Let us try to find the actual facts involved. Suppose that we set before us upon the table this heavy and substantial bit of marble, a small replica of a Greek Venus. What exactly is involved in its perception? First we discover grays, blacks, and whites. These refer at once to the visual apparatus. As our gaze rests upon the figure, the eyes move jerkily, fixating one point after another and so modifying the visual factors. With the shift in fixation comes a rubbing of the eyes against their sockets and the pulling of the ocular and facial muscles. These resources are enriched as we pass the hand over the surface; an exploration which also adds pressures from the fingers and hand. To all these details will be added a variable number of factors according to the experience and the predispositions of the observer. The perception is likely to include also auditory and other items which accompany the verbal forms of naming and description.

In the second place, these resources are definitely integrated and organized into the total function. The organization constantly undergoes modification as the eyes shift and the exploring hand wanders. The bodily factors in the perception then obviously include various receptor organs in the eyes, muscles, tendons, and the skin. The favorable setting and dis-

position of these organs of sense involve secondary devices which serve to increase and to specify the perceptual significance. Less obvious, but quite as important, is the implication of the central nervous system, as well as of the ingoing and outcoming lines of neural conduction.

The most obvious factor in the government of the function is extra-organic. The pattern and order of the physical energies reaching the organism are, so to say, arranged outside the body. But the orientation of the body, the formal and occasional instructions to observe this particular thing, and the neural trends of the moment are all governing factors which help to initiate and to direct the course of the perceptive function.

Historical government is less obvious; although the course of the operation and the character of the perceptual products are both determined in part by way of the past engagements of the organism; for, given the same general setting, the perceiving of the infant, of the child, and of the adult will notably differ from one another.

History also writes down its effects upon perceiving in a more rapid and striking way. To make the figure given (Fig. 1), the small non-conventional light-pattern represented in the upper lefthand corner by three black lines was flashed upon the retina of an observer at a considerable distance from the central *fovea,* where light-patterns always fall when we look directly at an object. After a momentary flash of this light-pattern into the eye, the observer was asked to draw what he saw. All the other objects in the figure (reading from left to right and line after line) are the drawings so made. You will see that this observer perceived about fifty successive times before the object perceived began definitely to resemble the light-pattern thrown upon the retina, and that it was near the seventieth trial that the object became stable and adequate to the impressed pattern. You might call

the earlier perceivings 'illusory' in view of their instability and inadequacy. Since these perceivings were interspersed through several days with other light-patterns, presented in an irregular order, and since the observer never saw the object in direct and foveal gaze until he had made all these drawings, we must conclude that the perceiving was gradually developed under repetition while the conditions outside the organism remained the same.

So much by way of a general indication of the nature and conditions of perceiving. The researches of the laboratory upon the subject and the descriptions of monographs and books usually concern quite specific problems. Let us examine samples of these.

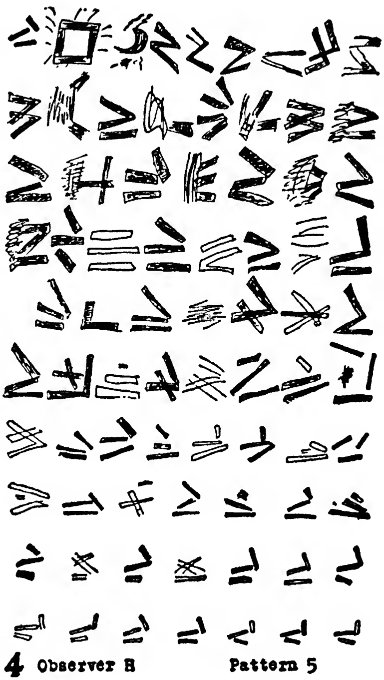


FIG. 1.—DRAWINGS OF PERCEIVED FIGURES AS A GIVEN LIGHT-PATTERN WAS IMPRESSED AGAIN AND AGAIN UPON THE PERIPHERAL RETINA

[From Drury, *Amer. J. Psychol.* (45, 1933, 640).]

When two rods are set at unlike distances before the eyes, the one is perceived as standing beyond the other. Although this may seem to you a perfectly natural and inevitable result, the psychologist has to ask quite concretely how the perception

of one object as near and the other as far actually comes about. That is to say, he is bound to inquire into the actual conditions under which this particular apprehension of distance occurs. The essential conditions do not lie alone in the table or floor stretching away under the rods, for a black cloth may be made to cut off the lower ends of the rods. Not in the background, for that may be made lightless. Not in the difference in apparent size or length of the rods, which may be equated. When all these aids to the perception of unlike distance are removed, the perception still persists. Then it may be discovered that the turning in of the two eyes (convergence) and the automatic adjustment of the focus of the two eyes to make the two rods appear clear (accommodation) are the main bodily agents responsible for the perceptive function which leads to the product, 'two like objects at different distances.'

Another example is the placing right or left of a signal-whistle heard in a dense fog. Visual factors are here useless because the blowing whistle cannot be seen. A clue is found by closing one ear. The perception of place is now more difficult and much less exact. It is a matter of the two ears operating together, as the two eyes coöperated in the last case. If, instead of coming freely through the air, the sound is led separately to the two ears by two separate tubes made exactly the same length and so arranged that they bring to the ears sounds of the same energy and phase, the sound is perceived as coming from a place either in or near the median plane of the body, no matter how far to the right or left the whistle is actually placed. By this experimental means, the psychologist discovers that the relative energies (right and left) of the divided sound and the exact times (phase) when the sound arrives at the two ears determine the perceptive placing of the signalling mechanism. If the sound reaches the farther ear a fraction of a wave length later than it reaches the nearer ear

(say, $\frac{1}{100}$-second later), the whistle will be perceived as lying on the side of the nearer ear. Here an extremely delicate device in the brain (beyond the point where the two auditory nerves come together) is primarily responsible for this acute perception of place.

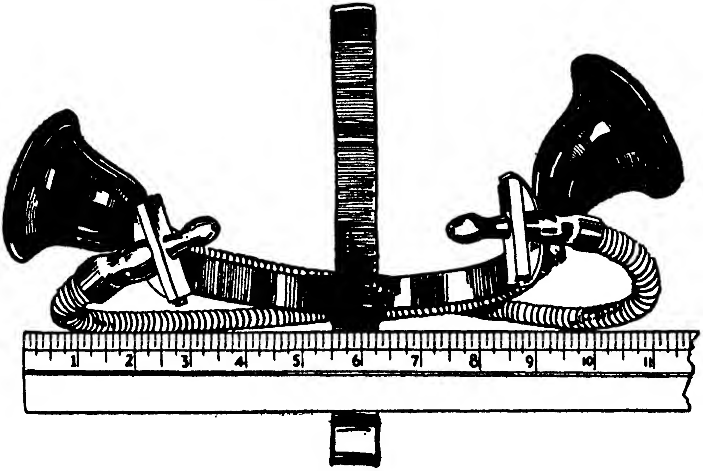


FIG. 2.—YOUNG'S REVERSING PSEUDOPHONE

The nipple introduced into the right ear leads to the horn-shaped opening on the left side of the head. The other half of the apparatus is similarly reversed. When the pseudophone is fixed upon the head, the subject, sitting with closed eyes, is inclined to hear sounds coming from the left (stimulating the right ear) as if they emanated from his right, and *vice versa.* [From Young (*J. Exper. Psychol.,* 11, 1924, 400)].

Other problems in perceiving which have been beautifully worked out in the laboratory of the psychologist are the following. How are unseen objects localized upon the skin? How do the two eyes coöperate in the perception of form? How delicately may sizes be distinguished by the fingers or by the tip of the tongue? Why do we invariably overestimate

vertical distances? What are the essential ingredients in the perception of the movement of objects seen and of objects explored by the hand? How accurately do we apprehend the duration of events? How keenly do we detect variations in rhythm and melody? The range and variety of these ques-

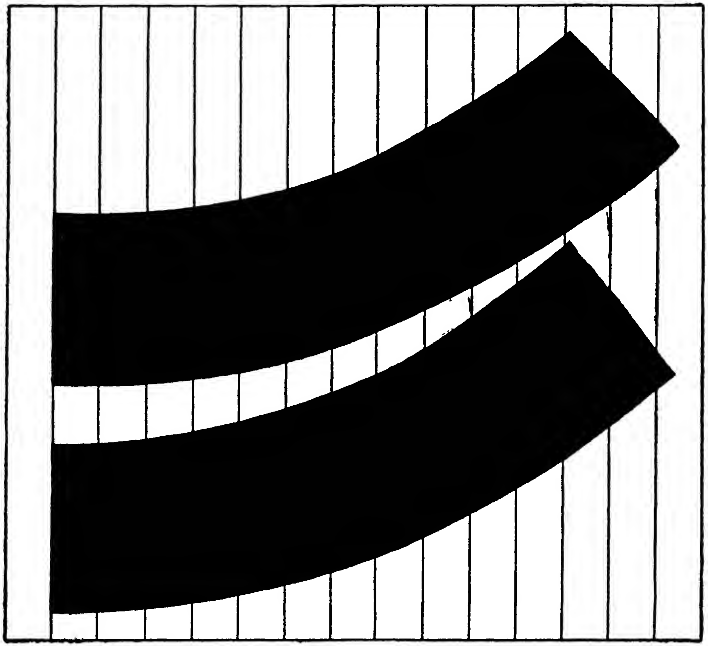


FIG. 3.—TWO IDENTICAL FORMS WHICH ARE SEEN AS UNLIKE IN SPITE OF THE VERTICAL PARALLELS

tions will suggest at once the richness and the attractiveness of the experimental field of perception. Our further discussion must be limited to a few of the typical problems and solutions. It is clearly impossible in a survey to cover the entire list.

Everyone is familiar with certain 'illusions of the senses';

the huge full-moon on the horizon, the shocking size of a tooth-cavity when explored by the tongue, the near approach of a distant mountain peak on a clear and frosty morning, and the "straight staff bent in a pool." So complex and so variable are the conditions of perception, especially of the spatial peculiarities of objects, that we are constantly falling into, and as consequently correcting, illusory apprehension of the common objects about us. Besides being striking curiosities of common life, these illusory perceptions have been very useful to the psychologist. They arise from perceivings where the perceived product is plainly ambiguous, distorted, or inadequate to the object, as we otherwise know it to be fashioned. A case of illusory extent is supplied by the identical patterns shown on page 40 which are seen as of unequal length because of their relative positions.

The inadequacy of the straight line to represent a given measured distance when the line is completed or accompanied by accessory lines is illustrated by the arrowhead illusion in Figure 4. Here the verticals in A and B and the middle lines in C are all drawn to the same length.

These illusions are psychologically useful, then, not because they represent any pathological disturbance of function, but because they call attention to the fact that the issue of the perceptive functions rests upon quite definite and determinable conditions either within or about the organism. In working out the exact secret of the illusory product, psychologists have learned a good deal about the functions themselves. The illusion tempts him to vary the conditions and so to modify the perception.

The arrowhead figure may, for example, be placed in its simplest form (Fig. 4, A, *a* and *b*) in an experimental way before an observer, with a device for changing the acute and the obtuse angles at the ends and also the actual length of the main line. The observer then compares the two central lines,

reporting which is longer with a given setting of angles. The main line *b* is then shortened, little by little, until the observer reports 'equal.' In a later set, the end-angles are slightly opened or closed and the line *b* again adjusted, little by little, until the report 'equal' is again reached. By noting the necessary reduction of the length of *b* with a whole series of angular

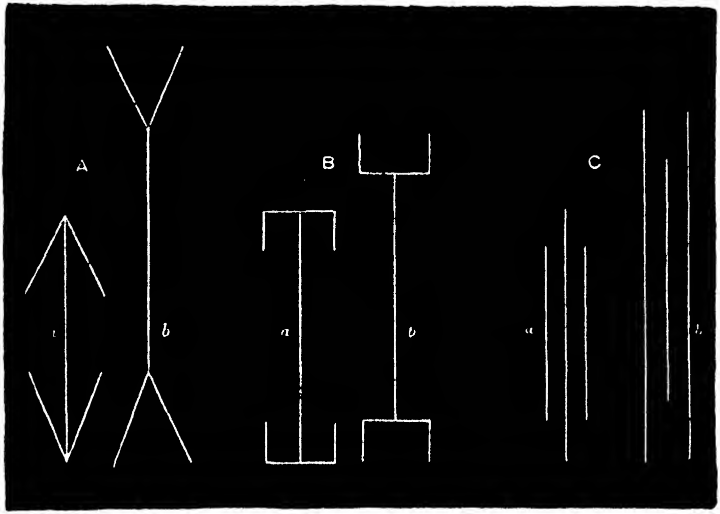


FIG 4.—THE MÜLLER-LYER ILLUSION OF LENGTH

[From E. B. Titchener, *Experimental Psychology* (The Macmillan Company, New York, 1901)]

changes, it is possible to discover just what part in the illusory perception of length is played by size-of-angle. In a similar way, length of the accessory lines, character of these lines (as in B and C), the omission of the lines on one side or the figure, the absolute length of the central line, the turning of the figures to the horizontal, and many other conditions of shrinkage and stretching, may be independently varied. Scores

of experiments of this kind have been carried through and have quantitatively determined once for all the exact part which each of these details plays in perceiving length within this general setting. Many other illusory perceptions have been experimentally studied in this way and thus a great deal of exact knowledge gained with respect to our perceivings. The experiments cover the auditory, tactual, and other means, as well as the visual. Not infrequently the psychologist has tried to bring all illusory perceptions under a single common theory of explanation. He has never succeeded, however, for the reason that one set of conditions underlies inadequacy and ambiguity in one case and another set in another. [13]

The Scope of Perception

We must allow perceptual apprehension of one kind or another to a good many of the animals; but the character and the extent of it vary within wide limits from one form to another. The enormous range of human perception far surpasses that of any other living being. This functional advantage in man seems to have been chiefly determined, however, by only two or three favorable circumstances. In the first place, by the wide variety of man's inventions and manufacture. The human world is full of the most heterogeneous objects to be perceived; not only natural objects but those which man has made with his own hands. In the second place, by special organic devices; the upright position, which gives to the eyes a commanding view and to the hands and arms a freedom of manipulation, and the double sense organs of sight (binocular vision) and sound (binaural hearing).

As regards the first, we can imagine the impoverishment of perception which should follow the loss of mechanical construction (furnishings, implements, tools, artistic objects, etc.) and the destruction of all those devices (telescope, microscope, phonograph, photograph, and motion-picture) which extend

our perceptions to the vast, the distant, the minute, the past, and the absent. No age and no region have exalted and expanded, so much as our own, the realm of perception. As regards the organic devices, no other animal is so well designed as man to specify and to break up the world by perceptive analysis. Other animals (*e.g.*, the ant and the dog) have gone further in the use made of an olfactory apparatus, although it does not appear that man could not surpass even here, were the conditions of life favorable; but the free use of the eyes as instruments of survey and analysis has carried human perception far beyond that of any other creature. It seems also necessary to add certain central or cerebral changes, not well known, which have enriched perception from the side of momentary and persisting central dispositions.

Binocular Stereoscopy

Consider the significance for perceiving of the two movable eyes set well forward in the head to permit at once a common field of vision and unlike views of one and the same subject. A large Cyclopean eye set in the middle of the forehead, present in some insects, would have missed this double view; and such eyes as the alligator or the hippopotamus possesses, set distantly at the two sides of the head, would have missed the common field of regard. Doubtless there are occasions when it is useful to the reptile to view first one river-bank and then the other; but we can scarcely imagine the delicacy and precision of human vision coming from the reptilian arrangement.

Let us see just what this binocular device does for our perceiving. We might expect that the double eye would somehow intensify our visual qualities, making colors more brilliant and lights more luminous. It does not; at least not to a useful degree. When you look at white paper or red cloth, covering first the right and then the left eye, you discover that either

eye by itself gives approximately the same color and the same brightness as both eyes together. The two eyes add nothing of this kind that is not given with one alone. Just so do the two ears add little or nothing to the intensity of sound. The advantage comes from another direction; a direction which you will apprehend if you will hold your forefinger upright six inches before your face and stare intently at the wall beyond it. As you close first one eye and then the other, you will notice that the finger seems to jump to one side and then to the other, and also that you first see it (with the left eye closed) from the right side and later (with the right eye closed) from the left side, *i.e.,* the direction is different and the point of view is different. The stimulus-patterns upon the two retinas are different and the two separate monocular perceptions are correspondingly different. When the eyes are stimulated together, however, the observer does not see two objects, neither does he acquire the two monocular views, either simultaneously or in succession. He sees one object, as in monocular vision, but with a different qualification. He sees the object in its proper perspective and with its proper depth or solidity. To realize how much binocular vision adds to our knowledge of near-lying objects you have only to ask some one to dangle a threaded needle before your closed eyes and then to call to you to open one eye and look when the needle has come to rest. If you do not see the supporting hand, you will discover that you cannot accurately estimate the distance of the needle from your face; but so soon as you look with both eyes the needle is immediately and exactly placed. To demonstrate the difference, bring up your own index finger from below to the precise spot where the point of the needle appears to be. [14]

Stereoscopic vision is most beautifully illustrated by the ordinary double flat drawings which spring into solid objects when placed in the common Brewster stereoscope (Fig. 5). The

figures are differently drawn, as you will see upon close inspection; but the difference disappears in the view, and instead of two slightly different flat figures, we have in our stereoscopic perception one pyramidal object. In making up slides by pho-

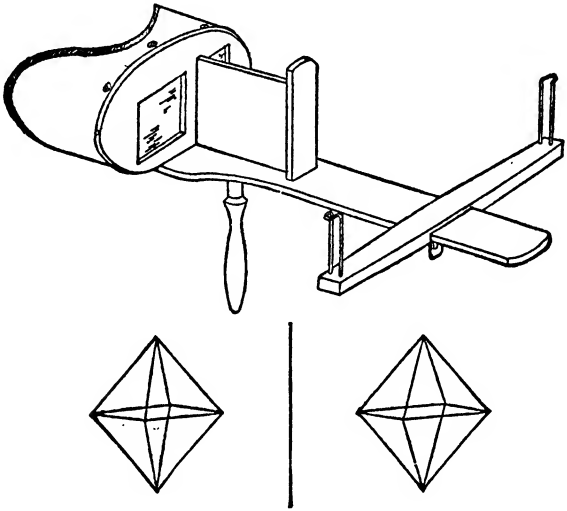


FIG. 5.—THE BREWSTER STEREOSCOPE AND A SAMPLE SLIDE

Prismatic lenses bring the slightly different stimulus patterns to the right and left retinas. [From E. B. Titchener, *Experimental Psychology* (The Macmillan Company, New York, 1901)].

tography the camera may be placed first to the right and again to the left of the view of the object which is sought; but usually a double camera is used. The difference in position may be considerably greater than that between the eyes (interocular distance), thus exaggerating the disparity. In this way the depth values of an object situated a long way off, too far

for direct stereoscopic vision, may be accentuated in the photographic reproduction. A simple instrumental device for demonstrating this effect of great disparity is the telestereoscope. Here two inclined mirrors placed before the two eyes give the effect of viewing the object with the left eye taken from its socket and held at arm's length upon the left and the right eye at arm's length upon the right. The result when one looks straight into the instrument is to produce curious distortions of perspective.

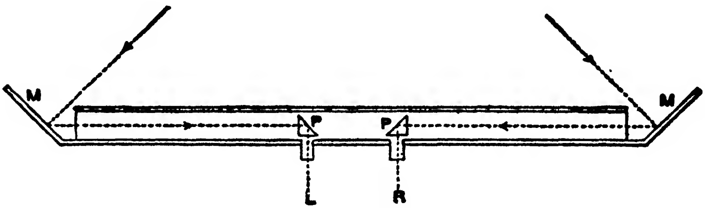


FIG. 6.—THE HELMHOLTZ TELESTEREOSCOPE

The rays strike mirrors at *M* and totally reflecting prisms at *P* before reaching the eyes at *L* and *R*. [From E. B. Titchener, *Experimental Psychology* (The Macmillan Company, New York, 1901)].

Stereoscopic perception is now utilized in the binocular microscope. By the employment of both eyes the tiny objects in the common field of vision are seen in their proper depth and perspective. Attempts made to add true stereoscopy to the moving picture, so rendering the shifting scenes more lifelike, have met with great difficulties. Perhaps it is not of great practical importance because the photographs impressed upon the film preserve the natural distribution of light and shade, the relative size of objects, change of position, atmospheric haze, and other aids to spatial perception (the *secondary criteria of distance,* as they are called). It should also

be observed that the retinal disparity, which comes from the right and left views of objects, is sufficiently marked to give depth only when the object seen stands relatively near the observer.

A great disparity in the two views sometimes leads to a doubling of the object. Hold two pencils in line before the eyes, one six inches away and the other fifteen inches. When you look at (fixate) the one pencil, thus bringing its light to corresponding areas of the two retinas, you may see the other pencil as two. The unfixated pencil is said to fall into *double images.* In fact, much of the field of vision is at all times properly disposed for double images; and nevertheless we do not see unfixated objects as double. We have no reason to believe that the doubleness is always actually there but neglected. What the large retinal disparity, which may *upon occasion* lead to the doubling of objects, usually does in the perception is to give unfixated objects their correct place and perspective in the entire field of vision. [15]

Besides the disparity of the retinal images, *i.e.,* the slight unlikeness or unlike spatial disposition of the two stimulus-patterns for vision, the devices for movement of the eyes play an important part in determining the spatial perception of objects both near and far. When a fixated object approaches the face, the crystalline lenses of the two eyes bulge under the action of the ciliary muscle and also the eyes turn inward (converge) toward the nose, thus keeping the stimulus-patterns upon the foveas or at least upon areas of clear vision. These physiological (motor) changes bring into existence muscular contractions which modify the spatial determinations. Finally, we must not lose sight of the fact that the spatial perception of distance is largely dependent upon functional trends and dispositions within the central nervous system. Two circumstances confirm this dependence in a striking way. First, the unlike visual estimation of a given

distance before and after we have traversed the interval by our own efforts, and, secondly, the effect of atmospheric changes upon perceived distance. In the second case, clarity and obscurity in the object directly affect the estimation quite without memorial revival or other aid. The hazy mountain immediately looks far away; the clear-cut mountain relatively near at hand. In the former case, we may temper the visual experience by revived strains and fatigue and so magnify the distance.

Tactual Perceptions

Tactual perceivings are similar to visual. They apprehend objects in their places or positions, of various sizes and shapes, at such and such distances, existing in assignable directions and under movement. In fact, we know that persons permanently deprived of sight from birth apprehend by tactual means all of these spatial qualifications of objects. The dermal mechanisms, then, taken together with central nervous processes, are adequate, as vision is, to the various spatial apprehensions. Nevertheless, a comparison of tactual with visual devices brings out three striking differences, to-wit: (1) the former usually involve non-dermal factors, (2) they refer as a rule to the body and to objects in contact with it, and (3) they are more gross and less exact in their operation. Consider in order these differences.

(1) To study the non-dermal factors, close your eyes and then ask some one to touch you at random with a pencil point. When the pencil comes into contact with your skin you are likely to 'see the place,' *i.e.,* the knowledge that the third left finger-tip or the right eyelid or the middle line of the forehead was touched usually comes in *visual* form. Usually but not always. You may find the words themselves 'left third finger-tip,' etc., running through in whisper; or finally you may find that the localizing is carried by an incipient pull of

the hand to sweep over and rub the place touched, or a shrug of the shoulder toward the place. Thus visual, verbal, or kinaesthetic factors have here borne the chief burden of the apprehensive function. But since the skin has, after all, furnished the only primary and ultimate clue to the place touched (remember that the eyes were closed), pressure excitations would seem to supply the basal elements in the perception. Psychologists have often argued so, and, in order to be consistent, they have endowed the tactual qualities with 'place signs' or 'local signs.'

For more than a generation psychologists turned their attention to the exact determination of these local signs and to the elaboration of theories for explaining them. The commonest method of experimentation was to apply together or in succession the two blunt points of aethesiometric compasses to some part of the body-surface of a blindfolded observer who had been instructed to report whether one or two places were touched. The smallest separation of the points which was apprehended as two was said to represent the 'space-threshold' or the 'two-point limen.' A better designation would be 'the discrimination of place or locality,' because it is really the apprehension of two positions or therenesses which the observer effects. To speak of a space-threshold implies that the points are mathematical points and that the line between is the smallest apprehendable space. Both assumptions are, of course, wrong.

(2) The special genius of perceivings in which the visual apparatus plays a primary rôle is to acquaint the organism with objects and happenings at a distance, the distance ranging from the nice scrutiny of objects held before the eyes to the apprehension of stellar contellations in the heavens. When the tactual apparatus is substituted for the visual we usually come down to the objects actually touching the skin or placed within the mouth or to the moving of

ctive objects over the body-surface. Experiment has shown ıat this close apprehension may be rendered much more elicate by careful and prolonged practice (as in handling bjects unseen or in reading the Braille letters of the blind); ut these tactual devices seldom compete with their visual ounterparts.

(3) The accuracy or delicacy of place-discrimination is oughly expressed in the following table, which makes it clear hat the conditions vary widely at different regions of the ody. The compass points were set down simultaneously. [16]

Tip of the tongue	1 mm.
Lips (red area)	5 mm.
Cheek	11 mm.
Forehead	23 mm.
Back of the hand	31 mm.
Lower leg	40 mm.
Middle of the back	68 mm.

The significance of these 'threshold' values considerably delined when the amount was discovered to be highly variable, lepending not only upon the place and the size of the area timulated but also upon the intensity and duration of stimılation, the instructions given, expectation, practice, fatigue, nd various other conditions. In fact, when men came to work vith fine stimulus-hairs, exciting only one or two pressure organs at a time, they found that the observer, under the nost favorable conditions of successive application, almost lways got separate localizations no matter how close the ressure organs lay to each other. More precise and painsaking reports of the observer showed, moreover, that the radual separation of the stimulating points did not lead up o a single exact position where the 'one-place' reports assed over abruptly to the 'two-place.' Instead, in a finely raded series, the careful observer reports such perceptions

as 'one-point,' 'short line,' 'oval,' 'blurred area,' 'dumb-bell figure' and 'two points.' These results again suggest that there is nothing like a sensory threshold involved. We perceive places, forms, figures, distances, and localities upon the skin in the same sense as we visually perceive the like qualifications of physical objects. [17]

The Perception of Moving Things

Often writers have spoken of a 'sensation of movement' and they have also based their descriptions upon that ambiguous phrase. But when we reflect that movement is usually a continuous modification of some spatial characteristic, we shall see that it is (at least in most cases) an aspect of apprehended objects—just as form, size, distance and place are.

Take any spatial aspect of objects that you please and consider it as undergoing a gradual and fairly rapid change. There you have movement. The toy balloon inflated by gas (size) or indented by the finger (shape) or cut loose and carried away (distance) or blown about by the wind (direction) or passed from hand to hand (place). All of these gradual changes we apprehend as movement. There is no more a 'sensation of movement' than there is a 'sensation of place' or of 'distance.' We apprehend movement just as we apprehend the other spatial attributes and relationships of objects. It has, however, one peculiarity which relates it to melody, rhythm and speech—a class of non-spatial perceptions. It is an *event.* Movement goes on. It is in progress. Many objects we regard as static. Not so movement, which happens.

Now what are the conditions adequate to the perception of movement? The unreflective answer of common sense is 'some object in motion.' But a moment's scrutiny of a moving electric sign above the street will convince any one that this answer is not quite adequate; or at least that motion in the stimulus is not necessary to the perception. A half-dozen

electric lamps set closely in a row and lighted in rapid succession will give rise to the apprehension of light running along, and the movement will become still more continuous and fluent when the lights are enclosed behind a long ground-glass screen. The electric bird which flaps its wings, the electric arm which strikes, the electric fan which opens and closes above the theatre, the electric mannikin which dances, are all light-patterns which fade and glow in rapid succession. The objects do not themselves move.

This perceiving of a moving object without actual movement in the stimulus makes possible the moving picture. Here the photographic film stops before the beam of light, is projected on the screen, and passes on to give place to another, slightly different, momentary exposure. Another familiar experience which shows that the shift of objects along the skin or of light over the retina is not the real condition of the perception of movement is the passing of the hand over objects upon the table or the roving of the eyes over the landscape. In spite of the continuous shift in stimulation in these cases, the objects explored are apprehended as themselves at rest. But it is a curious fact that when the eyeball is moved by the finger-tips, or by cerebral mechanisms in dizziness (as after rotation), then objects are seen in motion although we know that they are standing still.

A good deal of mystery has been made of the perception of movement. Most psychologists virtually admit that the mystery is inscrutable by declaring that the perception is native to the organism, that the individual is born with a capacity for apprehending movement; so they have recourse to a nativistic or genetic theory. The fundamental fact underlying this perception is that the perceptual field is continuous for any size and dimensions that we are able to apprehend. It is not a mosaic with empty interstices, as the dermal organs and the rods and cones are. The field of objects is *full,* so to

say. A steady change in any spatial qualification is then a continuous change; and that is all that movement is. It may be that, in some animals—perhaps the segmented worms—the only spatial qualifications are three vague and discrete *therenesses, i.e.,* 'ahead,' 'left,' and 'right'; but with us the objects either crowd each other or are separated by 'room'; there is one continuous field wherein all changes, that is to say movements, are, in a sense, equivalent.

One of the informing things about the conditions of movement is the lower limit. We do not ordinarily see the minute-hand move upon the watch dial; though we may see it move upon the huge tower clock when we climb up and observe it from inside. We sometimes say that we feel the cheek swell under the congestion of a toothache, and we can really feel the balloon move in our hands under inflation. What we really see in the first case is that the watch-hand is at different places at different times; what we feel in the second is that the skin is more tense and the inflamed flesh more painful than it earlier was. There is then a minimal rate below which movement is not perceived. There is also a minimal distance upon the sensitive surface for the apprehension of movement. This distance is different in direct and indirect vision, being influenced by the rotation of the eye itself, and it is also different again for tactual perceptions on various parts of the body-surface. This minimal distance seems to bear some relation to the delicacy of discrimination for locality.

As in the other spatial determinations, so here the illusory or inadequate forms bring us first-rate aid in understanding the essential bodily factors which underlie them. We are all accustomed to the illusory misplacements of movement; the moving train beside our window which makes our own car appear to move, the backward and forward movement of the landscape as we fly past, the fleeting moon across the apparently stationary clouds, the whirling of surrounding objects

in dizziness, and the floating movements of a small speck of light seen in a darkened space. In such instances the movement is read into the wrong objects under a variety of conditions.

Still more informing are those laboratory illusions of the successive lights and the moving pictures to which we have alluded. Here we have two fairly distinct cases. (1) In the first (the bare lights), the visual stimulus either moves along the retina or else tempts the eye to following movements. The illusion of movement arises provided the object observed is apprehended as one-and-the-same object in different places. If the lights flash slowly, so that we can count them as 'one, two, three, four, separate lights,' then, there is, as a rule, no apparent movement; but when they appear as 'that light while there and there and there,' then there is movement. But an opposite instance is the swing from the red to the green light when the traffic changes. It is obvious that any condition which tends to hold an object together in different places will favor the perception. The gradual tailing-off of the visual qualities and the after-effects which are shown in after image do just that. Psychologists have contended that it is the ligating effect of the positive after image which accounts for the perceived motion; but it has been shown experimentally that the perception may be obtained when extraneous filling takes the place of the after image or when the sequence is so slow that the after image dies out before the second stimulation begins. In these cases the persistence and continuity are guaranteed by some other means. The other means may be central and take the form of a predisposition or set to identify the object in spite of its translocation. If the conditions make it appear likely that one and the same object may pass from place to place, the observer is disposed to perceive the separate exposures as phases of movement.

(2) The second case is illustrated by the ordinary moving

picture. Here the same area of the retina—usually the fovea—is stimulated over and over by slightly different patterns. If these patterns give rise to consonant views, *i.e.,* views which *might be* views of one and the same object, then the movement perception is likely to arise. The comic animated creations upon the screen, which may be integrated from a few, widely different, drawings, show us how far an habituated attitude favoring movement will go upon slender materials. If the rate of succession is slower than about 0.5 seconds then movement-perception usually disintegrates. It is, however, possible to retain the perception of movement even when 'blank' intervals are plainly visible, with a sequence of exposures as slow as 6.0 seconds. But in this case, which may be produced by passing simple objects back and forth through a tunnel, the moving object is apprehended as alternately appearing and disappearing.

Within the last few years experiment has thrown new light upon the visual apprehension of movement, especially upon its change with the character, intensity, placing, and timing of the stimulating lights or colors. One interesting observation is that, when the two lights forming the sides of an acute angle are presented in succession to the eye, the one side seems to clap down upon the other. With a certain rapid sequence, there appears at times in the open area between the sides of the angle an unattached and shadowy movement, even though the sides themselves may appear to be at rest. Adherents of the doctrine of *Gestalt* have made much of this observation (which they call the phi-phenomenon), claiming this 'objectless' movement to be an ultimate datum in visual experience. Once we notice, however, that the perception of movement occurs readily and variously without any spatial displacement in the stimulating agent (*i.e.,* without an actual movement outside), we may expect to find all manner of curious 'illusory' movements as we change our outside condi-

tions and control our perceiving organism. The doctrine has not devised any convincing theory of cerebral action in these cases, and as for the facts of movement-perception themselves, we can produce, observe, and understand them quite as well without as with this popular and interesting theory. Other perceptions of the 'phi' sort of bare-movement we shall meet when we come to the *abstractive* forms of a later paragraph. [18]

Let us note one other important variant of the form of movement which we are considering. When the two bright sides of the angle are present at the same time, save that one of them begins a few thousandths of a second before the other begins or else ends a trifle before the other ends, there is still apprehended movement. With many other figures also movement thus appears when there is no sequence of stimulations, no gap between a first and a second figure, but only a slight difference in the exact moment when the two simultaneous light-patterns are thrown upon, or removed from, the eye. As the following graph indicates, the perception of movement appears more and more frequently (rising curve) as the *overlap* in time (initial and final) grows larger and larger. Along the (horizontal) line of abscissas is marked off the amount of overlap (in sigma $= \frac{1}{1000}$ sec.), and on the ordinate the number of trials in which the 'clapping' movement of one side of the angle appears. The graph clearly shows that an overlap as small as 6 sigma may lead to a perception of movement but that this perception comes more and more frequently as the overlap increases. The initial overlap is obviously more effective than the final. The experiment makes it evident, then, that, for perceived movement, it is not necessary to have the stimulating lights actually occur in sequence with an interval of time between, as was formerly maintained. The sequence and the 'empty' interval are usually realized in the motion picture, as everybody knows. Here each

presented view halts briefly before the projecting light, then the light is momentarily cut off while the next succeeding view is taking its place and coming to rest in its turn. But recent devices which employ moving lenses and non-stopping

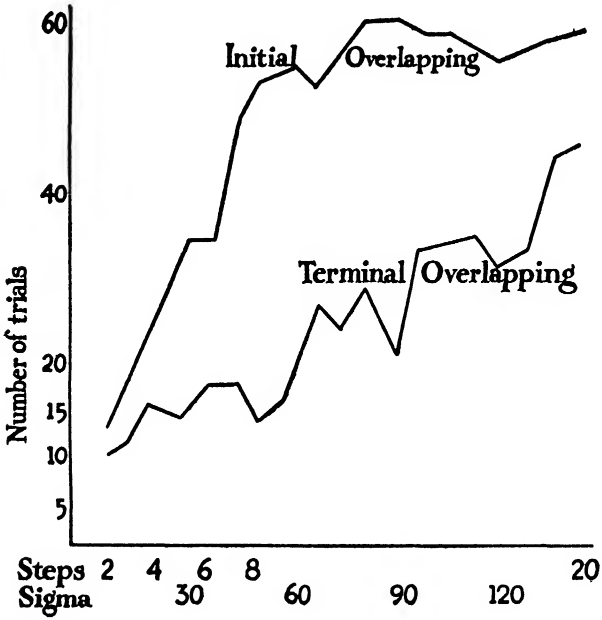


FIG. 7.—SIMULTANEOUS MOVEMENT WITH OVERLAP

[From McConnell (*J. Exper. Psychol.*, 10, 1927, 232-233)]

films, cause one view to glide directly into the next. These devices more nearly reproduce the conditions of ordinary vision, where the object seen as moving is gradually, and without halt or empty interval, shifted in space before our eyes.

The fact that the same sort of perceptive apprehensions may be secured through quite diverse bodily resources is well

illustrated above by the fact that a tone when presented to the two ears with a slight difference of phase is perceived as coming from a certain place; but when this phase-difference is slightly altered the source may appear to move right or left. Here is movement auditorily perceived, although the sounding body does not actually move. The case is similar with tactual patterns upon the hand or arm. A series of discrete and separate pressures following each other in quick order upon an ink-line printed on the skin will likewise produce a perception of tactual movement.

The effect upon a perceptive function of a slight change of

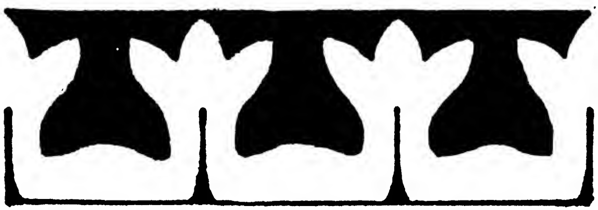


Fig. 8.—Ambiguous Patterns

[From Koffka (*Psychol. Bull.*, 10, 1922, 559)]

tuning of the organism is illustrated by the following wall-pattern, which will be seen either as three black T's or as a decorative white leaf-pattern. Here the stimulus (light) pattern upon the retina remains exactly the same while the perceived object changes. The change may be effected by some such instruction as "See this group of black T's" or "Observe the white leaf-pattern." At times the change in the perceived object comes spontaneously while one is simply allowing the eyes to rove over the object. The ambiguity in the product well illustrates the fact that the brain and other parts of the body are just as essentially concerned in apprehending as are the eyes, the ears, or the taste-organs in the tongue; and when

we come to the imaginational forms of apprehending, we shall see that all the organs of 'sensing' may, at the time of imagining, be entirely left out of account.

The Perception of Materials and of Work

You have been cautioned that it would be a mistake to suppose that all our perceived objects are spatial. While objects seem in our direct apprehension of the outside world to have been run into a spatial mold, a good deal of perceiving is related to the spatial forms only indirectly or by accident. We apprehend a book as made of paper leaves and cardboard covers just as directly as we see it to be rectangular or oblong, the ring as of dull lustrous gold and sparkling diamond as well as circular and thin. The solidity and whiteness are aspects of the perceived building just as length and height are. The locomotive engine is a vehicle bursting with energy and capable of accomplishing prodigious tasks. The tree is a growing, resisting thing which sustains its branches and holds commerce with the forces of nature. As before, our primary task is to describe the factors, physical and organic, which enter into this type of apprehensive function.

Since we cannot look into or tactually explore the contents of most solid objects and since we cannot directly see, hear, or touch the forces resident in active objects, it is natural to say that we infer these materials and dynamic qualities. Natural, but not correct. These perceptions are just as direct and immediate as the apprehension of size and shape. Instances are the perception of the smooth, cold, and solid ice that slips from the carrier's tongs and falls heavily in the street, the perception of heavy velvet hangings, of light and fleecy clouds, the tugging pull of the overladen tractor or the easy gliding movement of the powerful lomocotive, the fluffy pudding upon the plate, and the weak rotten wood exposed to weather. Perceiving of this sort is generally helped out either by the

aid of muscular movement or by the context in which the perceived material or event is set.

In the cold smooth ice seen to fall in the street or the soft velvet hangings seen across the room, the neural excitations immediately provided by the stimulus are supplemented from other bodily sources, and the supplements help to the apprehending of the object as cold or as soft. In the second case, incipient or mimetic movements are the chief resource in the apprehension of materials and energy. The late Theodor Lipps of Munich constructed an aesthetics of perception upon the contention that we read into objects and even into outline figures the forces and counterforces which we kinaesthetically apprehend in our own bodies. So the supporting pillar pulls itself up to meet the load of the entablature, the tree braces and exerts itself, the long horizontal line tends to sag under the force of gravity, and so on. The creation of perceptive character by bodily exertion is undeniable. Every automobile driver knows the fatiguing strain of helping his engine up a difficult grade and every golf player the unpremeditated attempt to guide the ball by strains and twists after it has left the face of his club.

While these kinaesthetic aids are not to be assumed in all perceptions, they are undoubtedly a common resource of the organism, especially in the apprehension of material and dynamic qualities. But we do at times literally see softness and weight, yieldingness and sharpness. While it is probable that those aspects of the world which we regard as tactual or kinaesthetic were originally mediated by these senses, short-cuts and other economies of the organism are constantly simplifying the means employed. Here 'seen' coldness, weight, and yieldingness seem primarily to depend upon the visual apparatus itself, together with its cerebral connections. Certainly there is no inference from seen spaces and shapes to something cold, heavy or soft. Thus visual excitations can

imply coldness as well as the thermal qualities themselves, tonal factors imply a small tingling object or a powerful, thundering dynamo; a bitter taste noxious food, and so on.

The Perception of Sound-Objects

As we have seen, the apprehension of objects and events as present does not necessarily imply that our perceived objects are geometrical. Now we proceed to objects which are actually non-spatial. They have neither place, shape, nor distance. A melody or a rhythm is as much of an object as a box or a tree or an express train. It does not include spatial peculiarities. A melody has neither size, linear diameter, nor height. Like movement it is an event; but an event which does not involve change of place. So too rhythm. So too the combination of vocal sounds in the sentence. These are spaceless objects. What are the factors necessary to their apprehension?

In a rhythm which is heard the stimulus is usually an ordered series of vibratory movements recurring with fixed temporal relations. Thus the regular click of the metronome furnishes the auditory stimulus to a simple rhythm. The stimulus is, at least in most auditory rhythms, usually augmented by pull of tendon and contraction of muscle. These supplement the auditory component. The tapping of the feet or the finger or the nod of the head in time with the sound may be taken as typical. Even when these overt movements are not observable, careful scrutiny will often find contractions of the muscles controlling the tympanic membrane of the ear, or modifications of breathing, or a pull upon the vocal cords, or minute inclinations of the head, or abdominal twitches. These movements seem to hold the rhythm-object together and to augment its significance. At times the auditory factor is wholly wanting, tactual and tendinous factors replacing it, as in a light tapping with the finger or a beating of the air with the hand and arm. The essential thing, on the side of

stimulus, is a regular repetition. The basis for rhythm lies in the temporal ligation or tying-together by the organic mechanisms. Two or more qualities with unlike temporal coefficients are bound together in the rhythmic unit and this unit is repeated time after time with slight variations. As thus bound together, each member has its individual place in the unit and each unit has its place in a larger complex. Variety in rhythm-object is as wide as the musical and metrical forms to be found in a given culture. As rhythmization is highly educable and subject to modification without change of stimulus, it appears that central sets and integrations play a large part in its organization. Central participation is easily demonstrated by the premeditated shift from one rhythmic form to another with an even succession of simple tones or noises. A pure visual rhythm seems to be obtainable only under high practice and experimental control, because of the fixed tendency of small and regular muscular and tendinous pulls to 'follow' visual stimuli which regularly recur, as do decorative groups on the façade of a building or pickets in a fence.

Melody is closely related to rhythm. On the side of stimulus it adds fixed relations of vibrational rate, and, on the side of the perceived object, intervals (*i.e.*, measured tonal distances) and a fixed basis or keynote about which, above and below, the melody swings. As a rule, the melody begins and ends with its basal note. Progression, then, in melody is similar to 'getting on' in movement. The melody 'moves' by advancing through tonal distances, as we say, upward and downward. That the 'movement' is not between fixed positions is shown by the fact that the melody remains while the key (and therefore its constituents) changes. Its object has greater significance than the rhythm-object, which it contains, so to say, within it. It would appear to be possible to construct a rudimentary melody by a progression of tonal intervals set together without measure and devoid of accent; but certainly melody

as we commonly know it implies the regular recurrence of the rhythmic unit. When we add to the rhythmic progression of the simple melody the chords and the clangs, those tonal objects which contain simultaneous fusions, we have at hand the principal resources of music, *i.e.*, we have those fundamental objects which when integrated in large masses are the sonatas, oratorios, symphonies, and other spaceless objects of our 'musical world.'

The Perception of the Body and of Its States and Conditions

In our common speech the word *self* is used with various connotations. Sometimes we mean by the self the individual who carries a name, fills a given place in the family, meets engagements, poses and postures in photographs, and otherwise occupies a unique and individual place in the family-social world. Sometimes we mean the author of our thoughts, the instigator and governor of our acts, and the bearer of our emotions; this self is supposed to think, will and feel; to be the activity behind our performances. We might call it the spiritual self. Again we may mean by self the body and its activities *plus* a mind. This is a more sophisticated notion. We might here speak of a psychological self. We should not ourselves posit such a self because we do not, in this book, invoke 'mental' processes and causes. In psychology we have to be on our guard against any notion of the self that will bring in a mysterious or magical being. That would be out of place. But we do perceive a self just as directly as we perceive trees, chairs, puffing engines, and musical forms; *i.e.*, we perceive the body. If the body perceived is one's own body, it may, to be sure, have qualities and references which distinguish it from the body of another. But it is, nevertheless, a plain product of perceptive apprehension. When later we come to describe the *self-object* we shall see that this object may involve

all sorts of functional resources (*e.g.*, emotive, actional, comprehending); but here we are concerned only with the self as a perceived body.

Fig. 9.—Perceptive Apprehension of the Bodily Self

[From E. Mach, *Die Analyse der Empfindungen, etc.* (Fischer, Jena, 1886)]

First of all, there is no doubt that vision plays a large part in this apprehension. The late Dr. Ernst Mach, eminent in physics, sense-physiology and psychology, has drawn a picture

of his visual self, as this object appears when viewed by the left eye alone. In the immediate foreground is the lofty dome of the eyebrow with the bridge of the nose showing at the right. Then the trunk; and beyond it the legs and feet. As thus drawn the bodily self has a curious detachment and objectivity. So have the views that we get in the mirror, in photographs, and in portrait paintings. These stand of course among thousands of 'views' that we get of the self every day; and they are further supplemented by tactual explorations, by turning the head, folding the hands, supporting and rubbing against the clothing, sitting, leaning, and standing.

Besides the visual and tactual resources for this perception, are the kinaesthetic. Every movement, every posture, every change of position calls into existence a 'here am I,' or 'I stretch my arms,' 'I support an object,' 'I stand rigid on my feet,' 'I bend,' 'I whirl,' and so on and on. Frequently this bodily self is just taken for granted, the organism being engaged, for the moment, with other objects or in thinking and planning; but many times during the day it does emerge either as a part of the perceptual scenery or as a unique object regarded on its own behalf.

Still we have not touched upon those factors in this apprehension which chiefly make the self intimate and peculiar. These resources are the visceral organs and processes and the somaesthetic or bodily qualities which rise from their varied functions. During the day the visceral processes complete a cycle whose phases are marked by fairly regular alterations in the vague obscure mass of bodily feeling. Upon awaking the elastic feel of health and vigor, pressure from the distended bladder, the vague ache of hunger (changing into pain, general lassitude, and weakness if the accustomed breakfast is long delayed), the comfort or discomfort of digestion, the gradual shifts in visceral well-being or ill-being which appear in the succession of moods, the alternations of hunger and

repletion, the general relaxation of the evening, the partial somatic anaesthesia of approaching sleep, in which the bodily self of perception is apt totally to lapse, and the curious and bizarre translocations of organic processes in the dream bring the organism around again to the beginning of a new cycle.

A peculiar and striking apprehension of the body appears when we lose our balance, as in rapid rotation or upon a sudden rise from a stooping position. When the loss of equilibrium is accompanied by an apparent whirling of objects round about and a general unsteadiness of gait and posture we speak of dizziness or giddiness. It was for a long time thought that a specific quality of dizziness derived from the stimulation of the disturbed semicircular canals; but such a quality has not been verified. We do know that the semicircular canals are set into function at these times, that they are intimately connected by nerve-fibers with the cerebellum and other central regions controlling movement, posture, and visceral function. We can understand, then, how almost the entire organism may be affected by whirling movements, as well as by disorder in the vestibular region of the ear; and how, therefore, the perception of the bodily self and of its condition of equilibrium may be profoundly affected. The perceived loss of bodily equilibrium is due in part to the general absence of control of those muscles which determine posture and position, in part to involuntary twitching movements of the eye which make the world whirl around, and again in part to the visceral disturbances of nausea which give a strange and uncomfortable coloring to the perceived state of the trunk.

That central trends in cerebral function may also be involved in these perceptions of disturbed equilibrium is shown by the effect of 'suggestion' upon seasickness and by the experimental demonstration that the perception may be removed by carefully controlled rotation of the body. Experi-

ments which involved a protracted series of methodical rotations, while the subject stood, sat, or lay flat, have shown that all the disturbing and distracting effects which commonly appear may be removed by sufficient practice. It is fortunate for the aviator that this is true, for loops, spins, rolls, and the like, which are at first very upsetting, all lose their disturbing sequels under habituation. Even the rapid twitching of the eyes (called nystagmus) fails to take place, as it does also in the highly trained dancer who regularly indulges in spins and whirls.

Abstractive Perceptions

In the perceptions which we have here discussed we have spoken of the object or the event as if a total and concrete bit of existence were always produced by perceiving. As a matter of fact, we never exhaust an object by any single apprehensive operation. We abstract this or that aspect for consideration. The thing perceived is usually partial or one-sided. In so far all perceptions are abstractions. Nevertheless, in most of the perceptions which we have considered, an object or an occurrence is implicit. When I perceive the top of the writing table to be about three feet by five feet, it is the table that has those dimensions. I do not simply perceive a ratio 3:5. So with the other instances. But we do at times leave the total object in the background and actually regard as present some phantom or ghost, as in the phi-movement above, instead of the real flesh-and-blood object. We do, after a fashion, perceive the grin without the cat. Let us examine typical cases.

An instance is to be found in perceiving duration. When we sit, hat or gloves in hand, in an outer office waiting to be called for an interview or for our turn with the dentist, we are likely to apprehend the passage of time. This apprehension is not the same as that of the temporal persistence of an

object. Time is here an event which is going rapidly or slowly. It is a going-on, and a going-on that is different from such durational objects as melody or rhythm. We apprehend this going-on in various ways. Some of the simpler ways may be confirmed by observing, in a passive state of absorption, the even flow of fine sand falling past a weakly illuminated opening in a lightless field. The seen flow is accompanied by a low, monotonous swishing noise from the sand. Under instruction to give himself up to whatever comes, the observer apprehends a mere temporal progress. The 'getting-on' attaches itself, under these experimental conditions, to the visual-auditory qualities. Gentle respiratory movements and eye-movements, together with the accompanying kinaesthesis, may be used under favorable conditions to the same end.

Many careful observations have also made it clear that psychological functioning at large has a durative aspect. When this aspect is related to a single quality in a functional pattern it is called sheer *durativeness* or *protensity*. Thus a sounding tone or a taste or a color 'endures' in this sense. It has protensity as well as quality and intensity or strength. This is psychologically different both from the perceptive 'getting-on' described a moment ago and from the apprehension that one event comes before another or lasts longer than that other. These temporal apprehensions are of time-relations and sequences.

A temporal sequence may be apprehended with clear sounds where the stimuli are separated by as little as 0.002 seconds, and down to 0.044 seconds with succeeding flashes presented to the eye. The discrimination of times has been studied in experiments on the 'time sense' where short intervals limited by clicks or flashes were compared to determine which was the longer. It was found that in very short intervals (up to 0.6 seconds) the limiting clicks or flashes were taken together as click-click or flash-flash. These very short times

seem hurried and produce discomfort. The total click-click or flash-flash is compared with another, rather than the tiny temporal gaps separating the succeeding clicks or flashes; intermediate times (0.6—5.0 seconds), on the contrary, are apprehended by way of their filling—chiefly tendinous strain; and larger intervals (5.0 seconds and above) are compared by means of secondary and outside means. Here the number of things running their several courses, the degree of fatigue, the tension and relaxation of expectation and fulfillment, shifts in mood, and changes outside the organism, all may be used as a basis of apprehension. [19]

Not much is known about the perception of times several minutes in length, but some unpublished experiments by the writer lead him to believe that certain obscure physiological processes may immediately touch off the verbal 'two minutes,' 'five minutes,' 'it's over' and so on. An astounding degree of accuracy for intervals as long as fifteen minutes appeared without any warning that the observer was getting on toward the end of the interval. Some such physiological alarum clock may be responsible for the arousal from sleep at a predetermined time. It seems to be required in the case of one of our observers who had an average deviation of less than five minutes for a series of predetermined arousals from sleep throughout the night. As the waking time was changed each night, we cannot suppose that an habitual set for a given time was gradually established by repetition.

Our surroundings are constantly giving us clues to the passage of time and to the temporal relations both in the outside panorama of events and within our own private world. It requires cleverness and pains to remove all these 'natural clocks,' and when we do we then discover that the active body is itself richly provided with its own time-keepers. These time-keepers reside in the organic conditions of hunger, repletion, breathing, fatigue, muscular activity, restlessness, and

the like, and they are augmented by the procedure of the psychological activities themselves. The waking anticipation of the day-to-come registers one duration and the recital of a long-learned poem another. If the disciple of the Yogi practices ever really attains 'timelessness' he does so only by stopping all the clocks, inside and outside, that commonly keep us *en rapport* with the steady march of life.

General Objects

A new and striking animal when first seen in the zoölogical gardens is apprehended less as an individual than as the representative of a class. '*So that*'—we exclaim—'is a giraffe!' 'At last a coati!' 'Oh! this is the way the hippopotamus looks!' The new creature has no personalizing marks. He is a new *that;* a specimen or type. White men often observe that all strange yellow men or black men look alike. That is because the rare specimens of an unknown race are just black men or yellow men. A generalizing apprehension identifies the specimen. No individualizing marks appear. Compare with the perceiving of one's own family or of a close associate in business. The tendency to generalize may be based upon a foolish racial prejudice or upon ignorance; but the ability to apprehend only the general or the typical is of very great importance. It takes us beyond the individual case in the direction of an undifferentiated kind. Generalization is by no means confined to thinking, as we are prone to believe. For in our perceptive intercourse with present objects and events also we learn to neglect the *thisness,* the individualizing aspects, and to consider the object or event merely as a representative of its class.

The collector and the taxonomist know the value of this generalizing tendency. The stamp, the coin, or the bird's egg is nothing as an individual; it is everything as a representative of an era or dynasty or variety. The systematic biologist learns

all the marks of the species, genus, family, and class, that he may put every specimen into its place among the forms of life. We all do the same with objects used as values and counters. The silver quarter and the five-dollar bill are nothing as metal and paper, as impress and ink; their whole nature consists in the amounts which they represent, valued in terms of goods which we may wish to possess.

The limit here of our generalizing is reached in the mathematical treatment of figures and groups. The Euclidian geometer works with lines, surfaces, and solids. He derives and verifies his theorems by drawing figures and working with them. His demonstration of the area of a given pentahedron or of the sum of the angles in a triangle does not apply to the figure in chalk upon the board. What he apprehends and what he bases his demonstration upon is a spatial figure of certain properties but without the filling of blackboard, wood, or metal. The blackboard space is not his space, the wooden cube is not his cube. His objects are space-objects without place, without time, and without material substances. They are mathematical objects; as real as stones and trees and plants, but belonging to a different order.

But in mathematics, and generally in the use of symbolic objects, we pass far beyond the limitations of perceptive apprehension. We must there include such operations as imagination, comprehension, and real or elaborative thinking. These operations we leave for later chapters. Here we only lay stress on the fact that we can, and frequently do, apprehend present objects and events as of a general character and not as specifying this or that particular thing or specimen or this or that actual happening. Although some non-human animals have been shown to possess the rudiments of this sort of generalizing, it is chiefly man, with his names and his action-words, who notably succeeds in creating these general objects and events. With a constant tendency to deal with

what is here and now, it is of great significance to man that he is able to devise nouns and verbs which signify the type or class as well as the individual thing. This is the beginning of *comment.* We shall meet it again; but here we note that we can, by its aid, greatly extend the range and the significance of our perceived world.

REMEMBERING AND IMAGINING

When we apprehend objects it is—as we have seen—by no means necessary that the objects apprehended should stand as present before the functioning organism. They may appear as objects that were present an hour ago or yesterday but now appear distinctly as existing at that definite time. Then, as we say, one is remembering. Presence, in that case, is the presence of yesterday; the object is apprehended as past, and past in the sense that it is lodged in the individual's own history. In this sense the memory is *my* memory. Here is a functional turn of very great interest and also of very great usefulness to any animal which has it in its repertory. It extends the career of the organism, making it cover both the panoramic scenes of today and the absent scenes of yesterday, last year, and many fragments of still earlier times. Thus the present gains in significance by being set into relation to these other times, and the past appears in its own peculiar right to fill in the framework of a connected life-course.

Again, the apprehension may appear as an anticipating. The noon chimes ring and I see the food-tables and the waiting line where I shall eagerly await my luncheon as soon as I can find my hat and rush down the street. To be sure, the cafeteria whither I hurry is familiar, and years hence, when I consider it from a distant scene, I shall doubtless remember it; but at this moment it is the place where-I-am-about-to-be. Here we extend our individual careers in a direction opposite

to memory, in the direction of the future or of the soon-to-exist-for-me. This is the root of imagining. As a first accomplishment of man and some other animals, it doubtless came before remembering. It is an easier accomplishment. It merely builds out the present, which is always supported in waking life, by adding a bit of the not-yet. Its great value to life is obvious. It allows the organism a modicum of the gift of prophecy. It lifts the veil of the future and so permits the body to prepare for the immediately inevitable. Indeed, it may change the inevitable, as when the first notes of a soulful croon lead one to silence the radio and thus save one's ears and temper. It frequently happens that the present itself actually holds a specific hint of the about-to-be. The screeching whistle of the hidden train may bring on the brakes and save a disaster at the railroad crossing. These tips of the immediate future we learn expertly to take, thus adjusting ourselves not only to what is here and now, as delivered in perceptive apprehension, but also to what will presently be an actuality. Since the present in perception is not a point but an extended segment of existence, gradually tailing off behind and gradually building up before, no exact and fixed line can be drawn between these two slightly different turns of functional activity. In fact, various intermediate cases occur in which it is wellnigh impossible to say just how far we are apprehending 'as present and now' and how much is a reaching out anticipatively toward the 'about to come.' It is only when we leap over the immediately-at-hand, leaving a gap and going on to more remote anticipations, that we commonly speak of imagining the future. The difference is, however, only one of degree, not of functional disparity. To be sure, the distant future is often got at by adding more elaborate operations. We imagine the weather of tomorrow by consulting the weather map, the calendar, and the present state of sun, wind or rain. We see ourselves as responding to a dinner-toast that

threatens from next week by composing phrases, by taking down a volume of after-dinner speeches, by inflating the lungs, straightening the spine, and what not. But in the end—if we really attain that bit of futurity—we commonly attain it apprehendingly and with the imaginational variety of that type of function.

The second direction in which our imaginings run appears in the form of an accompaniment to the main business of the moment. Thus, while we read the novel, we fill in the plot by an imaginal seeing and hearing of the characters and the scenery which set the story in panoramic form; while we listen to the plea of the defense, we supplement imaginationally in order that we may know the truth about the accused; while we hear the directions on the road, we likewise anticipate the turns in the strange road ahead.

The third way credited to imagination is the fictional way. Here we sail right away from the life-course, neglecting present, past and future, and build up events, situations, and performances in a possible or fancied corridor of existence. This comes still nearer to the stock form of the imaginational function. By virtue of it we create the world of phantasy and enter the Land of the Glittering Plain. Here once more we must distinguish that which is really apprehensional from performances which stand nearer thinking and emotion. These latter we shall consider in their turn.

It is important, since we are to study remembering as implying a specific reference to one's past, to distinguish between this function and those processes and products which we know as 'committing to memory' and 'learning by heart.' The more we 'commit' and the more thoroughly we 'learn,' the less do we remember in the strict sense. By saying a poem over and over we do, to be sure, secure it for future uses; but also we tend to cut it off from the past and prepare it for automatic recital. Who really *remembers* when he runs off "Mary had a

little lamb?" The past reference has quite escaped. The effects of time and of repetition we take account of in our subsequent study of learning. Here we keep quite strictly to that apprehending function where the pastness is inherent to the function itself, that is to say to the active remembering which matches, save for differences of tense, perceiving on the one side and imagining on the other. In the same way, we must learn to distinguish the real forms of imaginational construction—anticipative forecast, the running accompaniment, and the detached fiction—from those fusions with emotion and hard thinking which frequently are involved in creative tasks too often referred to imagination alone. [20]

Remembering and Perceiving

The difference between remembering and perceiving is often taken to mean that memory is a *mental* object whereas the perception is a *physical* object. This interpretation is wrong. The stamp window at the post office is, as I recall it, no more a mental window than is the same place when I actually stand before it and pay for postage. Both are known objects. One is the window as I stood before it yesterday; the other is this present window where I am laying down my money. This difference is, as you see, a *difference in functional product:* the objects and events produced by the function differ in time, in significance, and in setting. [21]

To understand the conditions under which we apprehend in the memorial or backward-referring way, we must return to perception; for the character, the fidelity, and the extent of memory ultimately rest in large part upon this antecedent function. It is probable that all the original conditions which influence the integrated perception affect also the issues of remembering. Experimental evidence bears out our general experience that vivid and coherent perceptions

lead up to—other conditions remaining the same—the most vivid, precise, and faithful memories.

There is one curious anomaly in memory which seems to stand against this rule. We might expect that the oftener a perception was repeated the clearer and more faithful would remembering appear. This is not true; at least not universally true. If you will examine your most vivid and most accurately localized memories, you will find that they usually refer to single and unrepeated perceptions. The absent lover is recalled as he stood at such and such a moment and on such and such a spot uttering such and such a thrilling declaration. An unduplicated experience! A memory to be vivid requires but one favorable impression. The reason seems to be that it must be temporally localized, and as soon as it refers to two or more preceding occasions it begins to be ambiguous in its reference. Like composite portraiture it acquires a haze of indistinctness. The common observation that it is difficult to recall with accuracy the features of an intimate acquaintance suggests the explanation that many views with many expressions and many plays of features have commingled to produce a total picture of shifting detail and uncertain reference. So Tennyson's complaint in *In Memoriam:*

> I cannot see the features right,
> When on the gloom I strive to paint
> The face I know; the hues are faint
> And mix with hollow masks of night.

Parting friends cherish a vivid last glance hoping that that will remain clear-cut and faithful, to be preserved by frequent memorial revivals and by other friendly devices, in spite of time.

It is, to be sure, incorrect to regard a memory as a copy of a perception. In strictness, we cannot say that any object is

'reproduced' or 'revived.' At this moment I see the hills as the fog half hid the eucalyptus trees in my walk of yesterday. The hill-fog-tree scene is almost the same as it was yesterday; although it is now mediated by a new set of factors and by a body that is, to some extent, changed. Because it is the same scene, we set up the fiction that it has somehow been stored away in brain cells and so preserved as a memory to delight us in reminiscence. There are two extraordinary things about remembering; first, that the body should be so impressionable and yet so tenacious as to be capable of repeating certain features of a complicated pattern in the absence of the original outside conditions; and, secondly, that it should be so delicately attuned to factors organized first under outside conditions and central conditions and then under central conditions alone that the same general scene (*e.g.*, the hill-fog-tree scene) should be presented upon both occasions.

We must not confuse *recognition* with a 'dated pastness.' In recognition, whether the object is perceived or remembered, the meaning is 'I know you' or 'the thing is known.' I recognize the delivery wagon of my grocer when I see it flying around the corner on two wheels; I recognize the letter that I remember to have received from my bank. It is 'that letter.' Along with the other aspects of the remembered object goes this aspect of being familiar. Again, and quite differently, stands the fact that this remembered object comes from my experiences of yesterday, or of Labor Day or Christmas, or that this thing happened on my twenty-first birthday. The remembered thing must be familiar, else it could not be referred to my experience; but it must also bear a memorial dating which is a different kind of reference. Now the conditions of the 'familiar' reference are various. An established connection may bring a name or other descriptive epithet; an attendant circumstance may supply context; or the subject may fit into a larger setting—as the street which one recog-

nizes because one is searching in a well-known part of the city. [22]

Conditions of the Memorial Functions

Our experimental knowledge of many of the conditions of memory (*e.g.*, the amount perceived, the character of the primary perception, its clearness and context, the intent to remember, practice, fatigue, and so on) is still imperfect; but it is certain that all these matters do affect both the fidelity with which the remembering represents the scene which it professes to return to the organism and the extent of the memorial recall. We know quite definitely that time affects the remembered scene by way of transformation and by way of decay and disintegration. The experiments of Philippe have demonstrated the tendency for the specific memory to be transformed in the direction of a stock type, *i.e.*, of some neutral and undated acquisition which, because of its fixity, is more useful than the particularized memory. Philippe casually presented to his subjects common objects. Days or weeks later, without any warning, he asked to have these objects drawn on paper. His subsequent comparison of the object and the drawing revealed this unintended shift to a stock type.

A similar change in memories is commonly induced by verbal description. When an acquaintance strikes us as tall, homely, or awkward, our declining memories of him are likely to be changed to conform to the stock 'tall,' 'homely' or 'awkward' man. A part of our surprise upon noting that a long absent acquaintance is not exactly as we had remembered him is due to the application of these verbal epithets which are apt to fit too loosely the individual case.

Again, there is some evidence that our simpler memories at least (as of colors and of grays) suffer modification through similar perceptual experiences subsequent to their registration. If that is true, then a remembered medium gray surface would

tend to grow lighter when the memory-interval was filled with light-gray perceptions and darker when filled with dark-gray perceptions. The wonder is that the bodily residues of perception, being various and multitudinous, do not *constantly* cross and commingle and so cancel all possibility of the dated and individualized memory. Everyone knows, once more, that remembering also depends upon the circumstances present during the memorial reinstatement of the event or object. In the return to the old home 'memories cluster,' as we say, about the old scene. In fact, any functional performance which lies near one's former experiences is likely to touch off a memorial apprehension. [23]

In looking for these conditions of remembering it is of the first importance to note that different factors enter into the *government* (see Chapter i) of remembering and perceiving. In remembering, the organic and historical factors of government and control are of primary efficacy, while in perceiving the extra-organic factors play the major rôle. When we perceive, the environment largely directs our functioning; but in remembering, the organism and its own history written into it take over the part played by the actual outside setting of the body.

Memory and Psychoanalysis

Capital is made of the individual localized memory in the clinical method of psychoanalysis. This method rests in part upon the doctrine that the residues of certain experiences become repressed or 'unconscious' memories afflicting the individual and inducing mental and bodily disorders. The method consists of an attempt to assist the memorial functions, *i.e.,* to 'bring to consciousness' (in the phrase of the psychoanalyst) the repressed memories. The practice of the method sometimes implies that remembering may itself, when induced, remove the disorder and so relieve the patient. To

explain the alleged curative effects of the exercise of these functions, the psychoanalysts have elaborated a theory of mind which makes it the seat of contending and conflicting forces, one of which is personified as the 'censor' who presides over the 'unconscious' and prevents repressed ideas from becoming conscious; prevents (in our terms) the carrying through of the memorial forms of the apprehensive functions. We must suppose that, in some cases, it blocks also the perceptive functions, as in the case of hysterical blindness and deafness, as well as the normal execution of acts, in impulsions, paralyses and automatisms.

Now it is of course possible to observe such striking facts as we have alluded to without accepting the intricate and highly speculative explanations in terms of unconsciousness, repression, the censor, and the like. Since we have not until now found it necessary to assume a separate and independent mental government, a dynamical agent, a set of contending powers, and a sea of unconsciousness, it may be better to remain close to the facts and to be content, for the time being, with more modest descriptions and explanations.

The psychologist has for a long time known that perception, and especially perception in an emotional setting, may leave upon the body a lasting effect. And it is more than thirty years since Breuer and Freud and some of the French physicians found, as they thought, that hysteria and allied disorders were to be traced to early, sometimes adolescent, experiences of a painful and disturbing character. The troubles had in some cases remained latent for years. A scar or trauma was supposed to have been left upon the organism. Reviving the ancient doctrine that memory is a storehouse and observing that the patient could not, without aid, reinstate the distressing experience, these men concluded that the memory was repressed and retained in the unconscious. We might of course say that every bit of psychological functioning of the memorial

kind which is not at the moment being carried through abides in a hypothetical 'unconscious' or 'sub-conscious'; but this would tell us no more than that, at the moment, the appropriate conditions for setting off these functions were not at hand. We might indeed carry the doctrine of the unconscious into new territory and say that the perceptions of to-morrow and of next week are in the unconscious. The only difference is that some of the conditions essential to unrealized perceptions lie outside the body whereas the conditions for memory are thought of as somehow attached to the organism or as carried by a permanent mind or self.

Some men believe that the memory itself (which we prefer to regard as a product of functioning and not as anything embedded in the organism) continues to exist in a latent or 'unconscious' form. We have no positive evidence to support this conjecture. We do know, however, that the functional residues may, under appropriate circumstances, lead to memorial activity. It also appears—and for this information we have to thank the psychoanalysts—that these residues are sometimes related, either as cause or as concomitant, to the symptoms or afflictions which occur in a wide variety of 'mental' disorders.

Psychoanalysis has also made it appear that the possibilities of memorial revival are much more extensive than any one had supposed. It suggests many new incentives to recall. Because human life is complex and human experiences highly individualized the memories when once they are elicited require a good deal of divination and guessing on the part of the physician or analyst. Since no one but the sufferer is likely to hold the key to a particular memorial situation, we can see the practical advantage to the clinician of having at hand types of characteristic experiences to guide him in interpreting and supplementing the memorial scraps which first come from the patient's laborious efforts to recover the past. Thus one

school looks for incidents connected with sex, another for thwarted desires of various kinds, and still another for old insults offered to the person and character of the patient.

It may be that in time a rational method of diagnosis will be evolved appropriate to the nature of the disorder and of its origin, and that this method will be supplemented by a wider knowledge of the proper means for evoking the memorial functions than we now possess. Apart from the therapeutic value of such clinical resources, the collection of a large number of memories would be a first-rate aid in reconstructing the total individual. Already the psychoanalytic literature abounds in gross depictions of individualizing differences to be found among human beings.

The Three Main Ways of Imagining

The memorial functions, as we have seen, always localize their objects in a single direction, *i.e.,* in the rememberer's past, while the imaginational functions are freer. Imagining takes—as we have seen—three principal directions. These we now briefly review in order.

Anticipation of the future. In their simplest forms these anticipations are easy to manage because they do not require the annihilation of the perceived present; they are rather organized, so to say, on the edge of it. The apprehension of present objects and events is extended to include future phases. We apprehend the coming of the wind when we see the trees begin to bend in the distant wood, the appearance of the noisy street car before it comes into view. The success of a game or a competition in skill similarly depends upon the anticipation of the opponent's movements. This imaginational extension, the root of imagination, is facilitated by our telepathic senses, sight and hearing, which serve to anticipate turns in experience and so to prepare for coming events. At this stage, the reference forward is just an appendage to the

perception. It is the present situation giving notice that it is about to suffer a change. The next step in our progress from the apprehended present is provided by the anticipated scene. Thus we hold 'in image' the appearance of the station and the train before we leave the house for the journey, the sound of the five o'clock whistle when the work of the afternoon begins to grow arduous, the sight of the audience-room where our address now under preparation is to be delivered. Here we have a temporal reference which is complementary in direction to the memory. It bounds the present on the opposite side. [24]

Conditions underlying this difference of past and future we do not fully know. It is easy to appeal to two separate powers of mind, memory and imagination, but the appeal gives us nothing but names. A more empirical solution points to the feeling of familiarity, alleged to be present in memory and absent in imagination. But we have seen that familiarity does not carry us far in memory. Since it is present also, in varying degrees, in perception, it is insufficient to supply a temporal placing. Imaginations, too, may be familiar. The visual image which means the railway-station-as-I-shall-see-it-in-an-hour may be wholly familiar and still refer to the future, and the imagery accompanying certain particular stanzas which I frequently find hypnagogic on wakeful nights is as familiar as the current copy of the *Atlantic* which I remember as having read last night; and yet the stanzas come with no memorial reference. No; familiarity and its want, or familiarity as contrasted with a positive feeling of strangeness or of novelty, is not a sufficient differentia of memory and imagination. Certain other differences have been suggested; the character of eye-movements, imitative and empathic attitudes, and the instability and coherence of the anticipative or memorial scene.

It is very doubtful whether these are essential differences

which really determine the reference in the one way or in the other. The exceptions to the rule make us skeptical. When we scrutinize the organized scene and observe how easily it fits in with the one function or the other, remembering or imagining, we are inclined to believe that it is rather the neural disposition, either momentary or sustained, together with the context supplied by the functional products, which determine the direction of reference. [25]

At times the mere intent to recollect or to previse is sufficient to divert a coming imaginal object toward a memorial or an imaginative function. Thus I say to myself "remember"; then open a book casually and read 'star' (the first word which strikes my glance). Immediately I am seated as a small child upon the doorstep in the evening reciting a wish, "Star, star, shining bright, etc.," as I look toward the heavens. Again I instruct myself "imagine," and turn to another page, read 'complexity,' and consider imaginatively the many aspects of the present subject which must be treated within these pages.

It is wholly likely that the memorial or imaginational inclination is encouraged by posture, eye-movement and mood; but we have no credible evidence that any particular set or active bodily attitude or mood is the universal and invariable condition of the one reference or the other. This skeptical view is encouraged by the fact that under experimental conditions we have, instead of two clearly defined classes, 'memories' and 'imaginations,' a large number of functional gradations exhibiting many differences of location, stability, richness, associative support, temporal setting, bodily reference, affective coloring, and so on. Thus we seem rather to find various points in a continuous series than sharply distinguished functions. [26]

The imaginational accompaniment. Next after the anticipatory reference in imagination we turn to the imaginational accompaniment. In the accessory material which runs along

with the novel we are reading, the thread of the plot is mainly carried in accompanying figures and scenes. Such an imaginal annotation, again, is an aid in the reading of history and in the comprehension of descriptive science. We have recourse to it also when we take part in conversation and when we listen to lectures and addresses. As we lose ourselves in the novel we are likely to build up a fictitious present and perceptually behold the creatures and events which are the joint creation of our author and of ourself. Here the externally aroused perceptions recede. The book, the table, the window, and the noises of the street lose their insistent reality. They generally hold together just enough to touch off and to maintain the fluent accompaniment, which finally becomes the main performance. Here the imaginational functions have a tendency to become perceptual. We are in the same kind of situation as when we regard a satisfactory moving picture, where the screen and the audience are left out of account (not really 'forgotten') while we simply observe. The success of the moving picture doubtless rests upon its ability to relieve the organism of preparing this imaginational construction while reading, and then of translating it into perceptual terms. The habitué of the picture theater immediately perceives. Both a defective command of language and a defective imaginational setting for the written page incline the feet of the public away from the library and toward the cinema.

Another form of imaginational accompaniment, a form frequently employed by the architect and the designer, concerns problems which appear in perceiving and for which perceiving is not adequate. Suppose that I find the door to my coal-bin in the cellar too narrow for comfort. I sit on an overturned box to view the possibilities of reconstruction. First I imaginatively take off the door-casing, find my saw, cut down the boards at the side of the opening, extend the top of the casing, miter the corners, etc. Here imagining accompanies my per-

ception in the form of a supplement. When to this process are added rules and modes of construction, as the architect and the artisan add them, we have an employment of imagination which does a great many important jobs whose solution is often, but erroneously, credited to real thinking.

The fiction. At one further remove from perceiving stands the detached fictional train. This variety is commonly known as phantasy or passive imagination. The reference is undated. Thus we let ourselves go in day-dreaming, we carry through imaginary conversations, or we think of the repartee that escaped us at the moment when we might have been brilliant. The relation to the present is remote. These imaginations are fragments of possible events, supposed bits of living. Here we have trains of events and scenes which are doubtless supported by a ligated series of functional events in the brain. In the verbal types, the picture-images are likely to be supplemented by a running conversation in which, as in Landor's *Imaginary Conversations* or in conversational dreams, the imaginer takes one part after another, adapting to each speaker his appropriate lines.

A large part of the 'active' or 'creative' imagination belongs to the elaborative functions or real thinking. As men propose and solve the problems of thinking by the symbolic use of verbal and other objects, so do they construct under the stress of some great desire a plan which is wrought out in the form of the novel, the drama, the sculpture, and the architectural creation. Here also appears something akin to the predicament which has been set down (Chap. i) as the central constituent of the emotion. The artist or author may create by virtue of a dramatic situation from which, at the moment, there appears no escape or solution. Rather does it supply an urge to painting, sculpture, or writing. The description of the elaborative functions and of the emotions involved in these creations must then be postponed to their appropriate place. Here we restrict

our inquiry as closely as we can to the apprehending functions.

But in so restricting ourselves we must not take too literally the 'creation' of the books. The word suggests—and many psychologists unfortunately confirm the suggestion—that remembering, anticipating, commenting and day-dreaming are purely passive and imitative functions in which the organism only regurgitates, echoes, and patches up the old; while real imagining devises its own materials and creates its own objects. The distinction belongs rather to aesthetics than to psychology. So far as it does touch psychology, it points, as we have just suggested, to the difference between the apprehending and the other functions and not to any contrasting pair of active and passive powers of 'mind.' Even in apprehending we cannot set perception down as a mere stamp of the die and memory as a mere 'reproduction' of the old. Each function is a new performance, however far it may be influenced by stimulus, predisposition, and central set. In the realm of memory and imagination these functions carry us to the connected and integrated scene, situation, or train which forms either the memorial recital or the integrated fiction.

Since the fictional kind of imagining is not biographical, *i.e.,* is not dated and bound to the individual's career, it may serve very exceptional purposes. As unattached, it contrives to turn out objects, scenes, and situations which are of *general significance.* Like the non-specific perceptions which we met earlier in the chapter, these fictitious products of imagination stand for a kind or class and thus carry us in the direction of the abstract. Instances are the imagined iceberg which floats in any cold sea and the imagined graceful bow which may be put to use in any drawing room and upon any formal occasion. These free scenes, free objects, and free occasions help man, as much as any functional mode within his reach, to pass beyond the dated and the local and to extend his knowledge beyond the actualities of space and time. And again, when we

come to examine comprehension and abstract thinking we shall see that the apprehensions at large, but particularly the fictional forms of imagining, have prepared the way for these new and powerful types of functioning.

We should not do full justice to the three main forms of apprehending functions, perceiving, remembering, and imagining, did we not observe that they are really three neighboring modes or procedures set along in a linear series. Their intimate relations are attested both by the easy way in which we glide from perceiving to remembering or imagining and back again to perceiving, and also by the discovery that in hallucinations (objects viewed as present where no object actually is) we have a kind of operation that stands midway between perception and imagination, and that in the panorama of the dream (where the scene is commonly 'here' and 'now') we have a strange substitute for a memory or an imagination, acquired with little or no support from stimulus and receptor. Apprehending is really a basal performance, then, always of the same general mode but variable in the ways which we have described.

The Government of the Apprehending Functions

At first sight it seems to be difficult to reconcile the close family relations within this whole group with the fact that the outside affairs of the world play so large a part in determining our perceivings while processes within the body, especially within the brain, play so large a part in remembering and imagining. The difficulty largely disappears, however, when we recall our observation in the first chapter that the organic and the extra-organic factors in government are always interactive; that "objects, energies, and human modes do not simply invade the organism to determine therein direction and control. The organism meets these determinants halfway. Its own state or condition is a co-determinant."

Now when we realize that perceiving is primary and that it prepares the organism for the other two functions, we shall see that the outside and the inside factors which are integrated in perceiving remain integrated for memory and imagination. We have then only to add the functional principle that the exercise of function economizes its future performances, making a part of the original organic support serve in place of the whole. While the neurologist knows very little about the mechanism of this economizing process, the fruits of it are wholly apparent. They appear, *e.g.*, in a striking way in the ease with which we drop out general and unnecessary movements when we are becoming skilled in the use of fingers and hands and also in the promptness with which the body comes to take up defensive attitudes when a blow impends, without the preliminaries which were at first necessary.

As for the difference in government in remembering and imagining, we have already noted several differential factors. Task and intent are of first importance, turning the organism toward the past or in the direction of one of the imaginations. Of next importance is the use of past products of the one function or the other, fitting the new product as it emerges into the concordant context of memories or imaginations.

When we come to consider the psychological disorders, we shall see that confusions of memory, imagination, and perception are very common there, and that these abnormal confusions usually rest either upon some disturbance in receptor or nerve tract—as when ringing noises in the head appear as voices of the absent—or upon some defect of government which has prevented the organism from carrying through a single function without a miscarriage or lapse. Misgovernment, which is the rule in many forms of insanity, plays havoc with the organism's functional integrity, thus disturbing the afflicted patient and making him 'beside himself' with fancied fears and a prey to foreboding and worry.

CHAPTER III

BODILY SUPPORT OF THE APPREHENDING FUNCTIONS

In describing the various ways of perceiving we have spoken of the use of the eyes, the ears, and the other organs of sense, of the muscles, and of the brain. Until now, however, we have not really attempted a serious description of these bodily mechanisms by which the organism contrives to apprehend objects and movements, materials and work, the body and its states, the passage of time, and the general reference of the individual thing.

When we approach the body with the query "How in the world do you manage to perceive all these objects, occasions, states and activities?" we propose a very difficult problem. And like queries with respect to remembering, imagining, understanding, and thinking promise to be still more difficult. An offhand answer, to be sure, is easy enough. The body might reply that it just opens its eyes and ears and stretches forth its exploring hand and so simply perceives; or that it uses the storage vaults of its brain for remembering and imagining, or that it settles down to hard brain work and thus comprehends and reasons out problems. But this would be magic, not science; for it would not soberly describe actual structures and operations that are adequate to the products of perceiving and the various other functions.

Another difficulty arises from the fact that many of the very same bodily facilities are used over and over in all of

these functions. If the body only served us as the handy pocket-knife serves at the picnic—supplying a large blade for cutting the bread, a small hatchet for firewood, a cork-screw for the olives, and a can-opener for the baked beans—our task would be light. But the living body is a very different sort of working system from the picnic tool. Just as it uses the mouth for ingesting and sampling food, for chewing, for breathing, and for speech, so does it variously use its neuro-muscular and other systems for the most varied sorts of psychological functioning. What we really need is to know all about the entire body and its processes before we begin our quest for resources. But that would mean, at the least, a working knowledge of anatomy, general physiology, neurology, endocrinology, and certain branches of biochemistry. With all that knowledge brought well down to date, we should still have our embarrassments, for this knowledge is woefully incomplete. The neurologist never has made a working plan of the nervous system that is adequate to the problems of perception, memory, and thinking. We have therefore to do the best we can with the knowledge at hand, and under the limitations of this book, we can, of course, only hint at and outline those bodily reserves which serve us in our psychological employments.

As for perceiving, we shall emphasize those bodily means which are especially employed when we do perceive, and repeat the same procedure for remembering and imagining, and then again for thinking and the rest, as we come to them, function by function. At the end we can put our bodily knowledge together, make an inventory of it, and thus see what must be left for further research.

In perceiving, then, we naturally begin with those organs of sense which are, as a rule, patently involved in the perceptive "apprehension of things and events as present and as going on now." We say 'as a rule' because in dreams and also

in anticipative forecasts of what is about to happen—both largely perceptive events—it can be shown that the sense-organ plays quite a subordinate, and, in some cases, a negligible, rôle. But we do say roughly that perceived objects 'come to our knowledge along the avenues of sense.' We turn then to the bodily receptors, reminding ourselves that those organs play their part only when they are in the intact body actively connected with all the big somatic systems.

The term 'receptor' suggests a receiving station. The receptors are not quite that. While they are the sensitive outposts of the nervous system, connecting by way of the nerves with the brain and spinal cord, they are really devices for initiating a nerve-impulse. This initiation takes place, as a rule, when some form of energy (light, heat, pressure, chemical change, etc.) is applied. The energy applied to the receptor is known as a *stimulus*. The receptor is thus touched off by the stimulus and then acts in its own proper manner. The stimulus excites or incites the receptor, *i.e.*, it causes in the receptor a release of energy which may then be transmitted in the form of a progressive electro-chemical change along a nerve and toward the central nervous system. Since the individual receptor is attuned to the form of stimulus which sets it into function, taken all together the receptors may be considered as special devices for representing within the nervous system the physical characteristics of agents and energies outside. Even in relatively simple organisms—*e.g.*, the amoeba—protoplasm is sensitive to certain forms of mechanical and chemical stimulation. When organisms came to be protected by an outer rind or shell, the more specialized forms of protoplasm in neural substance maintained this connection, by way of the receptor or sense organ, with outside energies. Each receptor is highly sensitive to at least one particular form of energy but relatively insensitive to other forms.

As we go over the various sense organs we shall discover

also that many of them possess accessory structures which serve to concentrate the energy or to intensify or otherwise modify it in the service of a specific energetic exchange between the body and the external world. Under certain conditions the nerve-trunk may itself be excited by a stimulus (*e.g.*, electric shock); but the receptor organs increase both the delicacy and the range of excitation. The nerve-impulse initiated, or prepared for, in the receptor may represent the strength, the form, the rate, the movement, the extent, or other qualification of the physical event contained in the stimulus. *We should not think of the stimulus exciting the receptor as the perceived object but always as a form of energy described in terms of the physicist.* Thus the visual stimulus is not the tree or the rainbow (which is the *product* of the perceptive function) but rather the pattern of radiant energy spread upon the sensitive surface of the retina and so exciting the visual receptors. That is what acts upon the organism. Many receptors lie wholly within the body (*e.g.*, in muscle-tissue or stomach-wall) and are then excited by energies released by some part of the body itself or by digestive substances within it.

Some visual receptors are excited only by a limited range of wave lengths of light and some auditory receptors by a certain narrow range of sound-frequencies. These receptors, as well as those of smell and taste, may be set into operation by incredibly small amounts of energy conveyed to the organism by light, sound, and the chemical changes brought to the tongue and the nose. The wide variety and functional differentiation of the receptors make the body, in effect, a receiving-set of extraordinary sensitivity, accurate 'tuning,' and wide range. To be sure, no direct provision is made for the reception of radiant energies (save in the heat rays) either below or above the narrow band of visible light, thus excluding the long and short radio-waves, ultra-violet, x-rays, gamma rays,

and cosmic rays. It is significant for our perceptive knowledge of those things and activities with which we have most to do, however, that the 'visible' rays which affect the eye are partially reflected from the surface of objects among which we move, and thus they afford the retina significant stimulus-patterns which give a clue to form, size, shape, color, and movement.

In thus dwelling upon the part played in our 'outside' apprehension by the receptors (exteroceptors), we should not overlook the fact just now hinted at that our psychological functions are just as truly served by receptors lodged in muscle, tendon and joint (proprioceptors) and in the visceral organs (interoceptors). Both of these kinds of 'inside' receptor are essential to our perceptive apprehension of bodily states and conditions and of the posture and movement of our bodily parts and members. They also come in as important bodily resources in action, emotion, and other types of psychological functioning still to be described.

We now consider the receptors group by group. [27]

The Visual Receptors

The retina contains highly specialized organs, the rods and cones, accessible to light and connected with the optic nerve. These structures and their immediate surroundings are the receptors for vision. They appear to be the seat of reversible processes which condition the light and color qualities. The most tenable theory of their function makes the rods responsible for the light qualities and the cones for both light and color. Very weak illumination excites the rods alone (twilight vision); light of moderate or of high energy both rods and cones. An observed shift in brightness from yellow toward green (Purkinje phenomenon) with decreased illumination appears to be due to the lapse of function in the cones, the rods having a relatively greater sensitivity in the green than in the yellow wave lengths.

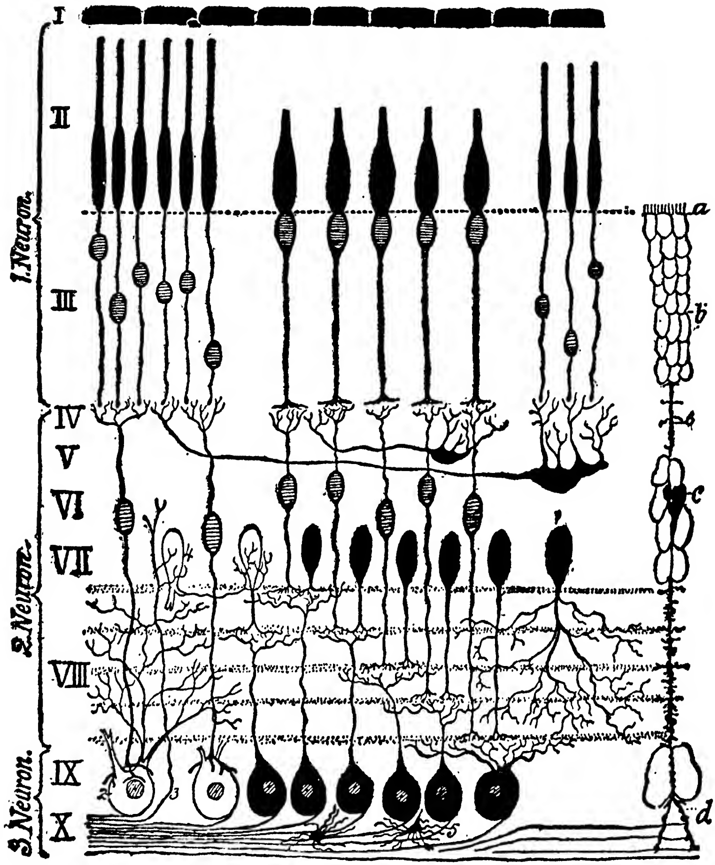


Fig. 10.—Schematic Representation of the Human Retina

The rods and cones lie in layers II and III. The rods (shown on the left at II) send impulses to the brain through fibers common to several of them. Each of the cones makes a connection with the brain through a separate fiber. The light enters at layer X and has to make its way inward to layers II and III before it sets up photochemical changes in the receptors, the rods and cones. The entire retina is very thin. [From W. H. Howell, *A Textbook of Physiology* (W. B. Saunders Company, Philadelphia, 1921)].

One explanation proposes six interrelated physiological processes, released or modified under light-energy in the cones, to account for the variety of hues. The interaction of the color-processes in the cones varies all the way from complete antagonism to almost complete support (with near-lying hues). Thus the facts of color mixture are made intelligible. The spatial distribution of rods and cones (cones only in the fovea, chiefly rods at the periphery) is used to explain the differences of central and peripheral vision; and the want or functional disturbance of certain of the color processes in the cones, the facts of partial and total color blindness. When we come to a review of the details of those perceptive functions which are initiated by the eye, we shall see that an understanding of the receptors—so far as our limited neurological knowledge goes—is of very great help; for these functions are in part determined by a dual (rod-cone) sense organ which is the seat of reversible processes of a chemical nature. Many details of the structure and functions of the receptors are still under debate.

In order to understand all the contributions which the eye makes to perceiving, we must remember that, with its sensitive retina, it is also a camera-like structure (see Fig. 11) of variable focal length, which spreads upon the concave retinal surface a small inverted and reversed stimulus-pattern which duplicates the light-pattern reflected from the surface of objects, from cloud-and-sky, and from the whole variegated and changing panorama which passes before the body. This stimulus-pattern on the retina may be further extended by moving the eyes, by moving the head around upon the neck, and by other bodily movements.

Although objects outside the body have no direct means of representing their various distances from the eye and their depth-dimension, as they extend straight away from the body, many clues to distance and depth are afforded by (1) the

light-and-shade patterns thrown into the eye, (2) actual and relative size of objects, (3) intervening objects, (4) haze and mist, (5) converging lines of perspective, (6) the slight difference in the light-patterns to right and left eyes (binocular parallax), (7) changes in the crystalline lens and the iris diaphragm (surrounding the pupil of the eye), both of which are under muscular control, (8) by the three pairs of muscles

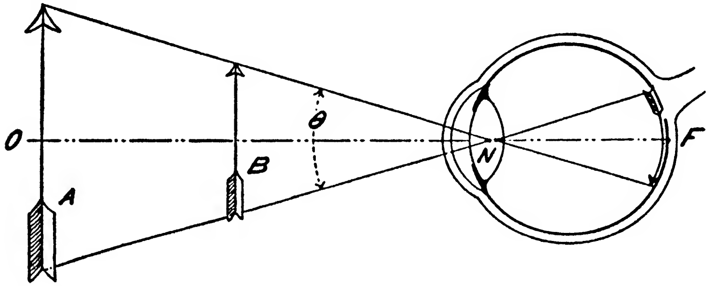


FIG. 11.—DIAGRAM TO SHOW THE OPTICAL ACTION OF THE EYE

[From L. T. Troland, *Principles of Psycho-physiology*, vol. ii (D. Van Nostrand Company, Inc., New York, 1930)]

which rotate each eye right-and-left and up-and-down, and by still other adjuncts and devices.

Figure 11 is a horizontal cross-section through one eye. It represents the way in which the light-pattern reflected from an object forms the retinal stimulus-pattern. At F is the fovea where vision is clearest. Above F (toward the nose) is shown the entrance of the optic nerve (the blind-spot). The black lines around N outline the crystalline lens, which bulges and flattens to change the focus of the eye. For the rest, the interior of the eye is filled with transparent liquids. In Figure 12 appear the outside (extrinsic) muscles which move the eye in its fat-lined socket. Light thrown upon the retina not only excites the visual receptors. It also governs the bulge of the lens and the size of the pupil, moves the two eyes conjointly

to direct them upon a common object, and also leads to various movements of head and body. This apparently simple organ, the eye, serves, therefore, the function of visual apprehension in a great many important ways.

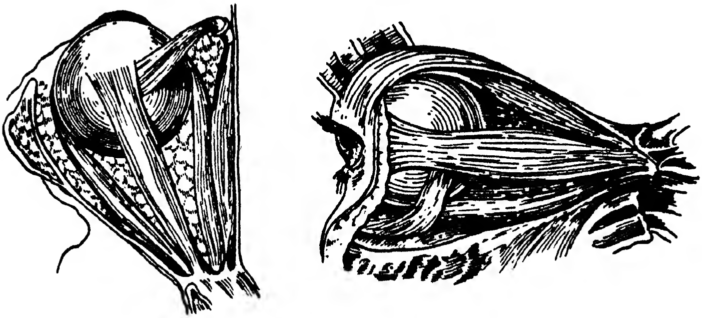


FIG. 12.—THE MUSCULAR GOVERNMENT OF EYE-MOVEMENTS

The left eye seen from above and from the temporal side. [From G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology* (Charles Scribner's Sons, New York, 1911)].

The Auditory Receptors

The receptors responsible for perceptions initiated by the ear are found in tiny hair-cells set in the organ of Corti within the snail-like cochlea or inner ear. You will be able to localize these microscopic structures when you take the more general view of the entire auditory mechanism as displayed in Figure 14. Here you can follow the physical sound-waves as they enter the outer ear (pinna) R, pass (as successive condensations and rarefactions of the air) to the drumhead or tympanum (T), are taken up by the small bones (ossicles) of the middle ear (P), and are continued, by way of the oval window, through the watery lymph of the vestibule, to the vestibular passage (Vt) of the coiled cochlea. It is in the floor of this ascending passage that the organ of Corti (the real organ

of hearing) is lodged. The view of this organ in Figure 13 below is highly magnified by microscopic enlargement. The observer's eye is in the plane of the floor of the vestibular passage. On the right of the figure the floor is yielding and membranous (basilar membrane); on the left, where the

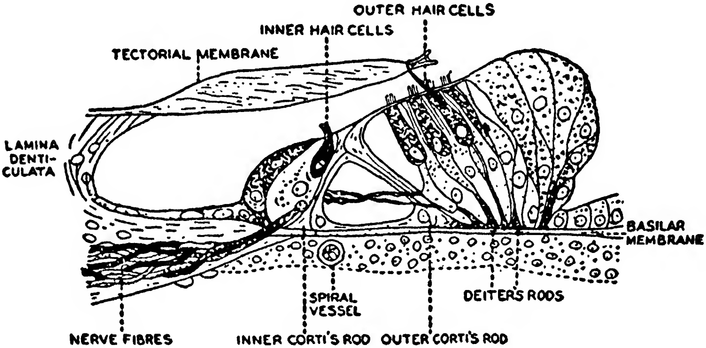


FIG. 13.—CORTI'S ORGAN

The tectorial membrane is shown contracted in the process of hardening the tissue, and torn away from the organ of Corti. [After Retzius, from H. Fletcher, *Speech and Hearing* (D. Van Nostrand Company, New York, 1929)].

nerve-fibers come out, it is a bony shelf which extends in a spiral from the bony center that runs straight up the cochlea. If you will measure the pinna (R) of the figure below with your pencil and then measure your own, you will see that this general plan of the ear is just about life-size. There are thousands of hair-cells in the organ of Corti. These hair-cells are probably the real receptors for sound. They are excited by vibratory changes of pressure in the fluid which bathes them and which fills the vestibular passage. The tectorial membrane (above them) may play a part in their excitation. You will observe that these receptor cells are connected with the nerve-fibers at the left (Fig. 13). All the thousands of

these nerve-fibers compose the acoustic branch of the VIIIth nerve and so connect the receptors with the brain.

Most sounds which find their way to the auditory receptors in vibrational forms of energy are physically com-

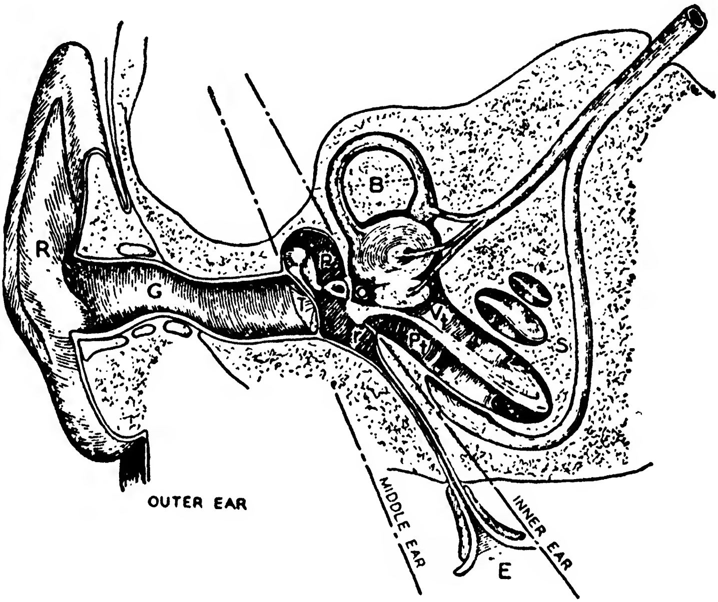


FIG. 14.—A SEMI-DIAGRAMMATIC SECTION THROUGH THE RIGHT EAR

The cochlea (S) shows the spiral bony shelf, running upward between the two vestibules (Vt and Pt) and supplying the attachment for the basilar membrane. The cochlear branch of the VIIIth nerve comes out at the base of the cochlea (Czermak). [From H. Fletcher, *Speech and Hearing* (D. Van Nostrand Company, New York, 1929)].

plex. Even so elemental a sound as the note of the violin is analysable into a number of physical components (see Fig. 15). Such sounds as we hear from the whole orchestra, in the

street, and over the radio, are very much more complex. But observe that, although the whole complicated disturbance of

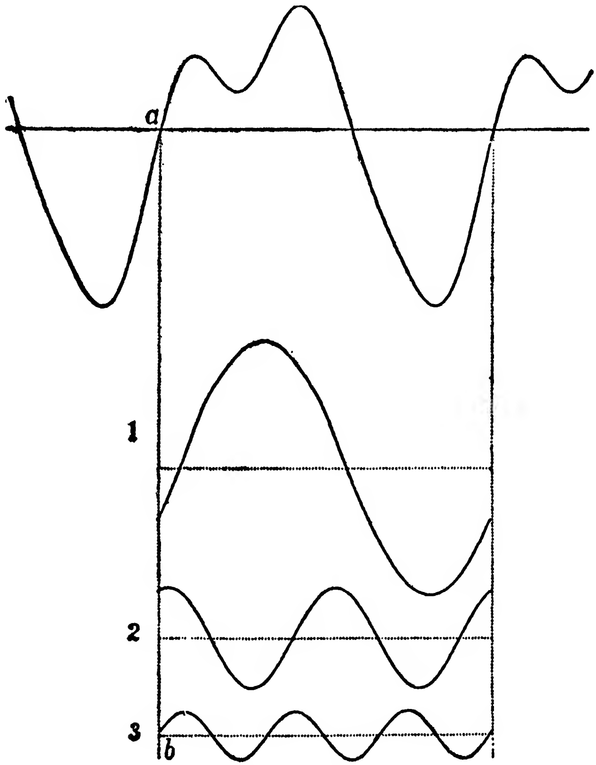


FIG. 15.—THE CURVE AT THE TOP (a) REPRESENTS A VIOLIN NOTE; THE THREE CURVES BELOW (1, 2, 3), ITS PENDULAR COMPONENTS

[From D. C. Miller, *The Science of Musical Sounds* (The Macmillan Company, New York, 1916)]

the air as it comes to the ear is one, *i.e.*, physically unanalysed, we hear sounds individually. We 'hear out' the solo voice with an orchestral accompaniment. We hear separately the rattle

of coal, the chug of the motor, and the roar of the train. We hear the announcer and the subdued music as we listen to a broadcast. It is obvious that the 'hearing out' of individual tones from such a complex aërial disturbance as that produced by many instruments or voices calls for some organic means of recovering the component parts of the acoustical wave-train. The stimulus is one; that is to say, the air does not separately convey in vibrational form the displacement caused by each instrument or each voice. Only an algebraical resultant is transmitted. From this resultant some organic means must be found to account for the ability of the organism to hear analytically. Up to a certain point of complexity the ear usually analyzes according to Fourier's law, *i.e.*, resolves the complex disturbance into simple pendular components, components which correspond, on the physical side, to the simple tones. [28]

The basilar membrane of the cochlea is a thin plate of tissue with strong cross fibers stretched from the central bony shelf of the cochlea to the outer wall. These tense fibers vary in length and in mass. Helmholtz thought that they 'sympathetically' vibrate, each with its proper rate, and in vibrating set into function the hair cells adjacent to them. The various hair cells thus specifically respond in function to the various rates and so produce the tones. Noise, then, would arise from large masses of unselected cells with no—or only a gross—analysis. [29]

The Receptors of Taste and of Smell

The receptor organ for taste, the taste bud, is a definite and fairly constant structure (Fig. 16). The taste buds are pear-shaped organs, containing parallel cells which end (at least some of them) at the moist mucous surface of the tongue in one or more pores through which protrude hairlike terminals. Here the sapid substance in solution is supposed to excite

the receptor. On the human tongue the taste buds usually occur in the side walls of papillae of one form or another. The small, bright red fungiform papilla is easily recognized on the upper surface; as are also other types of papilla. Besides the top and lateral surfaces of the tongue, some adjacent structures also contain taste buds, which are, however, much more widely distributed in the embryonic and infantile stages of development. In the adult there is a long blank tasteless area at the center of the tongue on its upper surface.

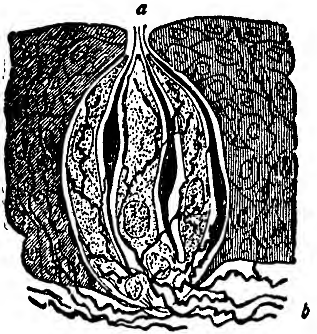


Fig. 16.—Taste Bud
a, taste pore; b, nerve fibers

[From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)]

At least a partial differentiation of function among the buds is suggested by various facts. One is that the tip of the tongue is most sensitive to sweet, the lateral edges to sour, and the base of the tongue to bitter. Another significant observation is that when the individual papillae are separately stimulated by solutions of sugar, common salt, and so on, certain papillae give rise to four taste qualities, others to three, still others to two, and a few to one quality only. There is thus seen to be a consistent relation between the chemical substances acting as stimuli and the specific function of the various receptors. At least three nerves innervate the tongue and appear to share in transmitting the excitation from the receptors to the brain.

The taste buds are widely distributed among the vertebrates, being present as far down as the amphibia. In certain fishes (*e.g.*, the catfish) they are thickly distributed over the

body surface and on the barbels, as well as in the mouth. Similar nervous organs are also found among invertebrate forms. [30]

The neural element in the receptor for smell bears a general resemblance to the taste cell. It is a cylindrical or spindle-

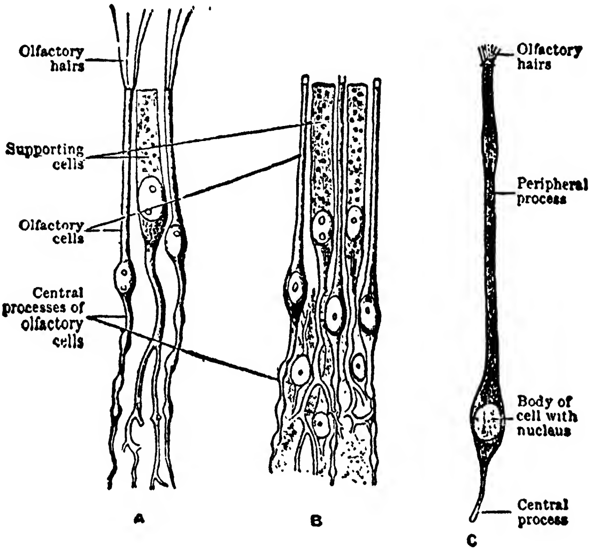


FIG. 17.—OLFACTORY RECEPTOR CELLS

A is from the frog; *B* and *C* from man. [From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)].

shaped cell (Fig. 17) lodged in the olfactory epithelium, a small patch in the upper part of the nasal respiratory tract. At the distal end of the olfactory cell are a few hairs, sometimes long enough to be called lashes or flagella.

These olfactory hairs are regarded as the real receptor organs. As they are bathed in watery mucus it appears that

the chemical stimulus must be dissolved before it is effective for excitation. Inasmuch as the hairs themselves are oily lipoid substances, insoluble in water, the stimulating substance would have also to be soluble—as it appears—in oil, in order to

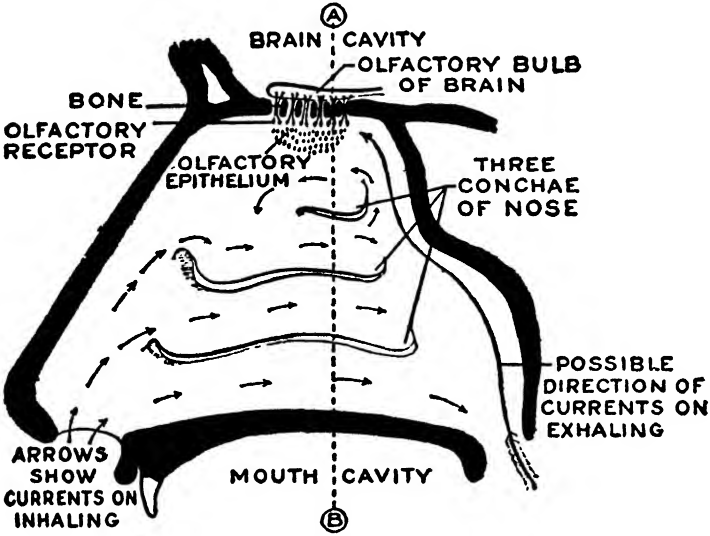


FIG. 18.—RIGHT NASAL CAVITY IN MAN

The arrows indicate the air-currents within the nose, the olfactory receptors, and the adjacent olfactory bulb on the brain-floor. [From H. C. Warren and L. Carmichael, *Elements of Human Psychology* (Houghton Mifflin Company, Boston, 1930)].

excite the hair cells. The fact that a vast number of chemical substances, often present in incredibly small amount, give rise to smell shows the great delicacy of the receptors. The presence in the olfactory epithelium of free nerve-endings, believed to emanate from the trigeminal (Vth) nerve, is significant in connection with the fact that non-olfactory qualities must carefully be distinguished from smells proper. Sheldon

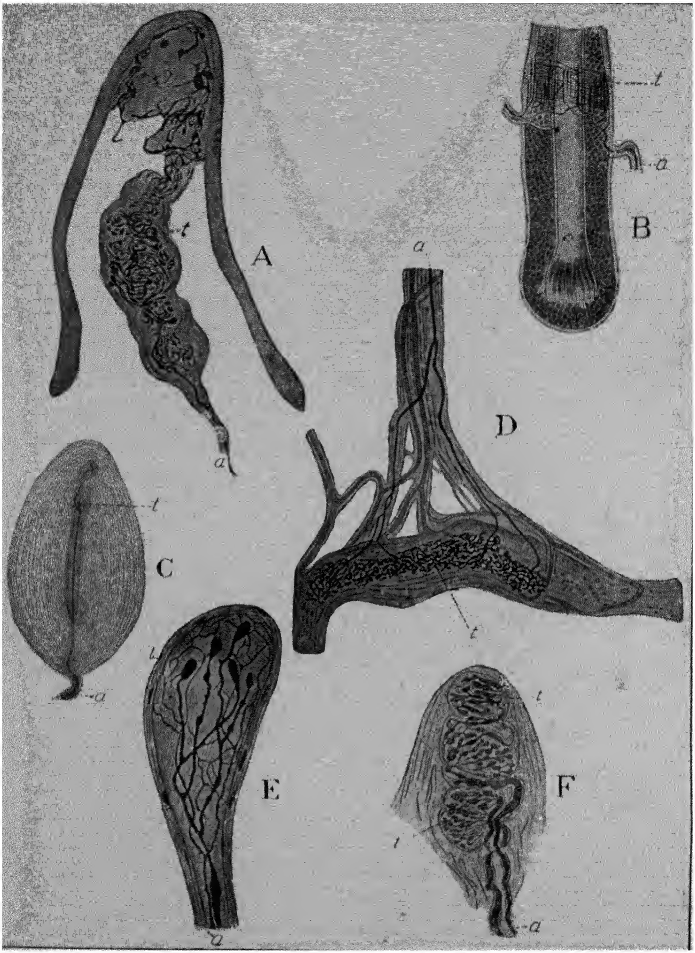


FIG. 19.—NERVOUS TERMINATIONS IN SKIN, MUSCLE, AND TENDON

In each case *a* refers to the axone and *t* to the ending of the nerve fiber. *A,* Dogiel's Corpuscle; *B,* section through a hair and hair sheath of a cat; *C,* Pacinian body, from cat's mesentery; *D,* Ruffini's corpuscle; *E,* Golgi-Mazzoni corpuscle; *F,* Meissner's corpuscle. [After Luigi Luciani, *Human Physiology* (The Macmillan Company, New York, 1917)].

found that dogfish continued to react to oil of cloves, pennyroyal, thyme, and other substances in the nostril, after the olfactory apparatus had been destroyed, but failed to react when the trigeminal had been severed. The present writer is inclined to believe that the non-olfactory components still play a conspicuous and confusing rôle in the determination and classification of smells. [31]

The Receptors for the Somaesthetic Senses

Although a histological examination of the skin reveals a wide variety of specialized nerve-endings, the psychologist has little positive knowledge of the functions which these may subserve in tactual perceptions. The best-attested relationship is that between the pressure qualities and the nerve-endings wrapped about the root of each hair. On hairless areas it is quite probable that the Meissner corpuscles are excited by a deforming pressure of the skin; but here the certain, or even the probable, relations of nerve-ending to the apprehension of specific somaesthetic qualities come to an end. Attempts have been made to correlate cold and warmth with Golgi-Mazzoni organs and the corpuscles of Ruffini, respectively; but every investigation made by sectioning the skin below temperature-sensitive spots has yielded results which do not confirm this functional relation.

The great number of pain-sensitive points in a unit-area forces the conclusion that cutaneous pain can be mediated only by free nerve-endings in the skin, since this is the only type of nerve-ending occurring in numbers great enough to explain the facts of observation. In regions below the skin, the paucity of nerve-endings found has led psychologists to conclude that muscular pressure must be mediated by the muscle-spindles, tendinous strain by free nerve-endings in the tendinous sheath, and articular pressure by similar endings in or near the joints. [32]

Nerves and Conduction Paths

The receptors would be useless were they not functionally connected with the brain. This connection, as Figure 20 shows,

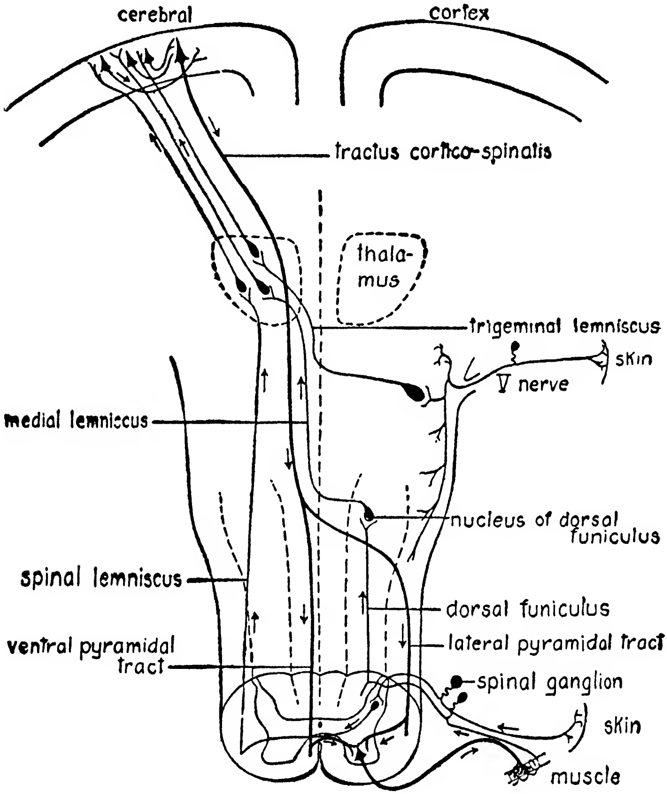


FIG. 20.—AFFERENT PATHWAYS EXTENDING BY WAY OF THE SPINAL CORD FROM RECEPTORS IN THE SKIN TO THE CEREBRAL CORTEX

A motor pathway running from the cortex to a muscle is also shown. [From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)].

is made through the afferent pathways which reach the brain by way of the spinal cord and the brain stem. The structural unit of the connecting tracts is the *neurone,* a modified cell from which ordinarily project axones and dendrites, minute threadlike processes which serve to connect one neurone with another (cf. Fig. 21). In an intact nervous system, neural excitations usually enter the neurone by way of the dendrites and leave by way of the axones.

Chiefly as a result of advances made in the use of the vacuum tube, the last decade has brought a marked increase in our knowledge of these neural excitations, especially of the transmission of the nerve-impulse along the longer axones which make up the trunk of a nerve. Almost a century ago the first measurements of the speed of the nervous impulse had been made; and these had shown that this speed varied from one animal to another and from one type of nerve to another, averaging about 100 meters a second in man. Where Descartes had conceived of the nerve-impulse as a 'wind or very fine flame' which travelled through the 'pores' of the nervous system, we know now that we have to deal with an electro-chemical wave of excitation which passes along through the substance of the neurone. It has been shown that this wave is accompanied by the production of carbon dioxide and by the generation of small amounts of heat. The passage of the impulse is also indicated by changes in the electrical potential of the nerve as the wave of excitation sweeps along it. Using the cathode-ray oscillograph, Gasser and Erlanger were able to show that the active portion of the nerve at any moment is electrically negative to the rest of the nerve; and experiments with other apparatus have yielded similar results. As a result of these and many allied researches we now know the neuronal impulse most significantly by way of this wave of negativity, which serves as a delicate and reliable indicator of many of the characteristics of the impulse.

The investigations of the physiologist yield the unmistakable suggestion that this nerve-impulse is the same in character for all nerves, and, indeed, for all animals. Moreover, the work of Lucas and many others has given us the 'all-or-none' law of

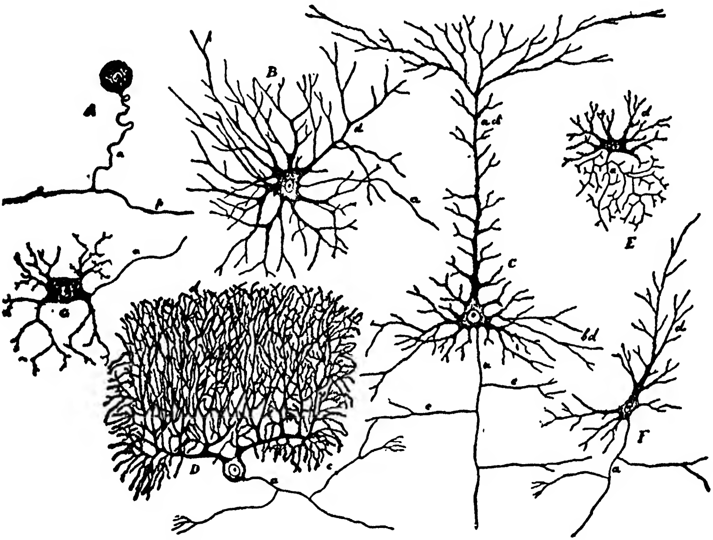


FIG. 21.—VARIOUS TYPES OF NEURONE OR NERVE-CELL FOUND IN THE BRAIN, SPINAL CORD, AND NERVES

A, from spinal ganglion; *B,* from ventral horn of spinal cord; *C,* from cerebral cortex; *D,* from cerebellar cortex; *E,* from spinal cord; *F,* from cerebral cortex; *G,* sympathetic ganglion cells. [From C. M. Jackson, *Morris' Human Anatomy* (P. Blakiston's Son and Co., Philadelphia, 1925)].

nerve activity which declares that a nerve, if it conducts at all, conducts with the maximal intensity of which it is capable at the moment. Once this is granted, we are faced with the problem as to how intensity is signalled in a nervous system where all impulses are of the same nature and where every

nerve-fiber operates at maximal intensity whenever it discharges. The answer is to be found in the researches of Adrian and those who have followed him. It may be stated as follows: "Intensity cannot be signalled by strength of nervous impulse; it may be given either in terms of frequency of response of a single nerve-fiber, or in terms of the number of fibers involved."

Thus you may see how conceptions of neural activity have changed. Until recently it was thought that the stimulus entered the nerve at the receptor and passed along it to the brain, a conception reflected in much of our common thought and conversation. Now we may regard it as definitely established that the action of the stimulus is comparable to that of a finger on the trigger. The pull on the trigger serves to release the energy already present in the cartridge; a hard pull does not fire the gun with any greater intensity than the weakest pull that will fire it at all. The utilization of this discovery will correct many tendencies to loose thinking. It will prevent any careless statement to the effect that the light or the sound 'passes along the nerve to the brain,' for we now believe that the only thing that passes to the brain is a common type of nerve-impulse which the light, the sound, or other stimulus, acting on the receptor, serves only to release. [33]

Neurones are, as a rule, to be anatomically distinct, although joined in function by close approximation of the dendrites of one or more neurones to the axones of others. This area of functional contact is called the *synapse;* and it is supposed that it acts as a sort of valve, allowing impulses to pass only in one direction. Certainly it is a fact that neural excitations will pass only from the axone of one neurone to the dendrites of the next whenever a synapse is involved, although the impulse is capable of passing in either direction in an isolated axone. In addition, it is commonly supposed that the resistance at the synapse varies, decreasing with use; so that

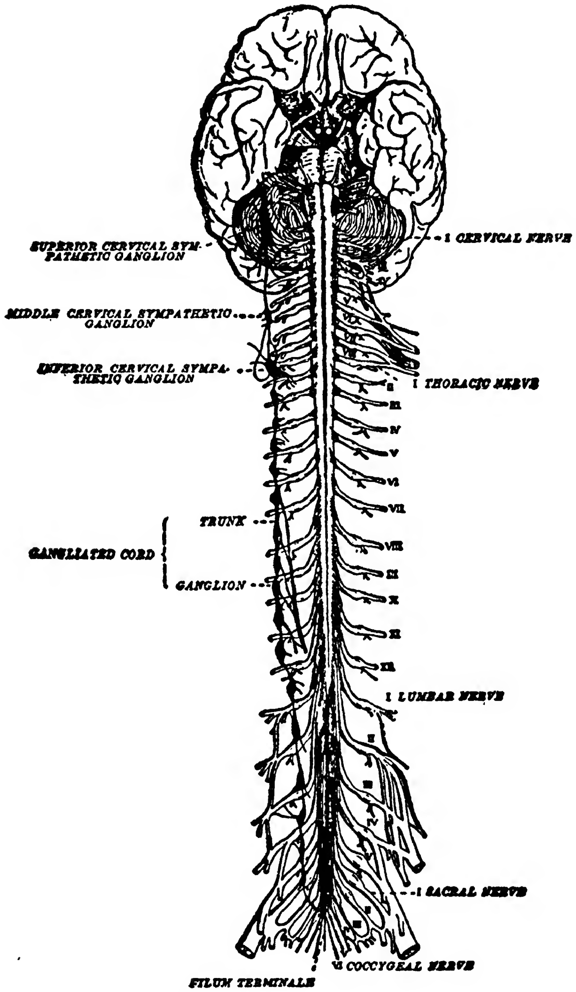


FIG. 22.—THE CENTRAL NERVOUS SYSTEM

This shows the cerebro-spinal nerves and, in black, the *autonomic system.* [From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)].

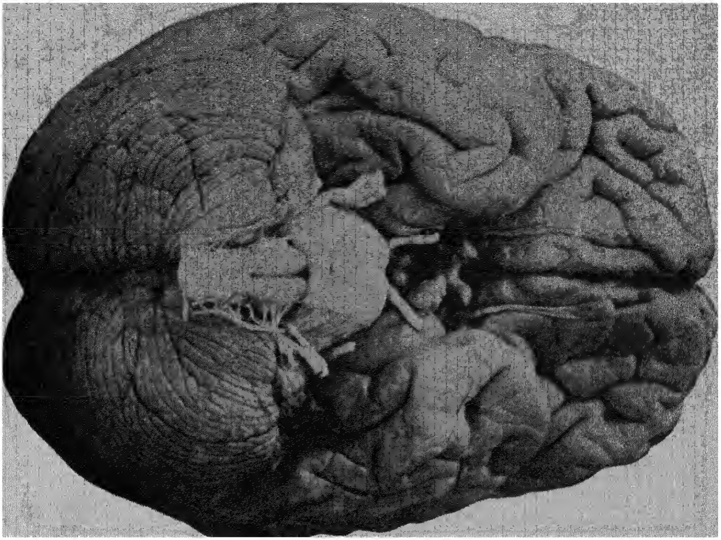


FIG. 23.—BASAL VIEW OF THE ADULT HUMAN BRAIN

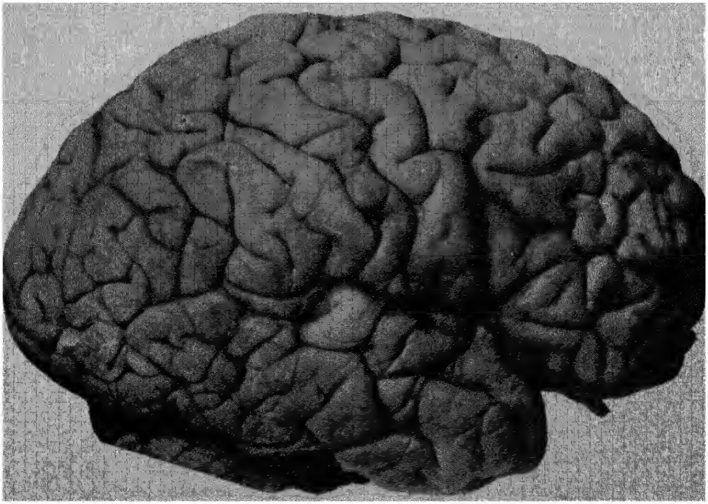


FIG. 24.—VIEW OF THE RIGHT SIDE OF THE ADULT HUMAN BRAIN
[After Retzius, *Das Menschenhirn* (Stockholm, 1896)]

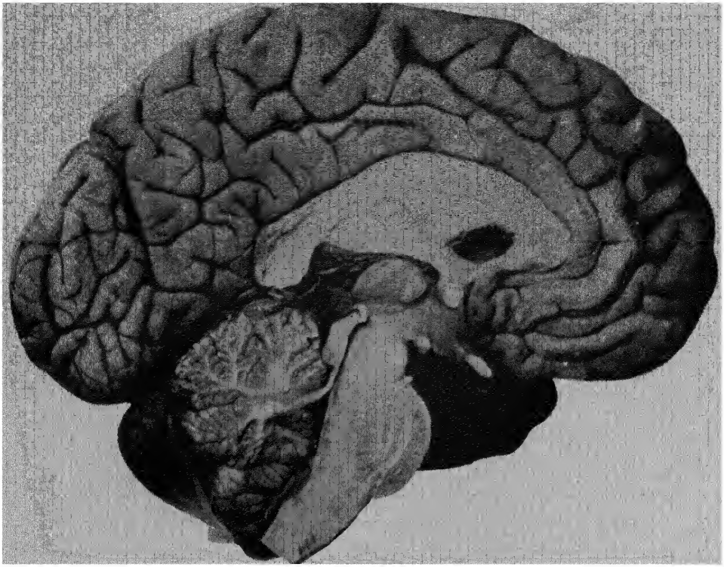


FIG. 25.—VERTICAL MEDIAN SECTION OF THE ADULT HUMAN BRAIN

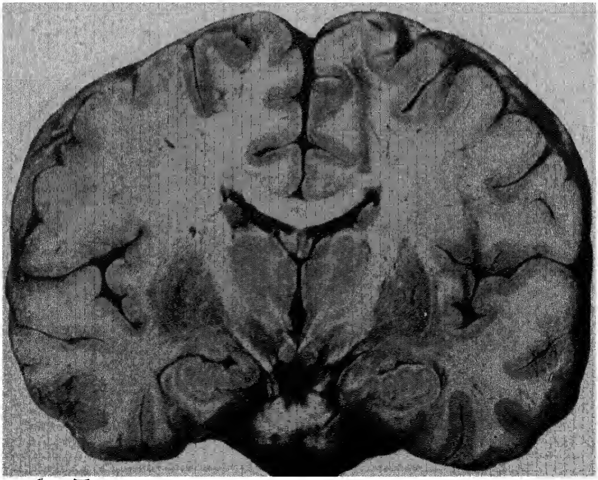


FIG. 26.—TRANSVERSE SECTION OF THE ADULT HUMAN BRAIN, SHOWING THE WHITE AND GRAY REGIONS

[After Retzius, *Das Menschenhirn* (Stockholm, 1896)]

impulses pass more easily over paths which have been in frequent use. No experimental evidence on this point is available, however. The hypothesis is based chiefly on the facts of learning and habituation.

The Brain

Neural impulses from the receptors, coming by way of the conduction pathways, constantly reach the brain in great numbers. They come by the thousands through the *spinal* and *cranial nerves,* entering the brain or the spinal cord. A less direct set of conducting pathways from the brain outward is afforded by the *sympathetic* or *autonomic system* which supplies viscera, smooth and striped muscles, glands, and other organs and tissues of the body. Its functional connection with the brain is partly through large ganglionic masses interposed between the cerebro-spinal pathways and the autonomic tracts. The brain itself is a vast mass of neurones exhibiting regional differentiation and organized into functional systems of great complexity. Where the cell-bodies predominate, as in the cortex or 'rind' of the cerebral and cerebellar hemispheres, the brain wears upon transection a grayish appearance (gray matter). Where the axonal processes, bound together in fibrous strands, are in abundance (as in the great conduction paths) the substance looks white (white matter). The whiteness is due to the white (myelin) sheath which surrounds the axis cylinder, the core of the axone.

Three great tracts of the interconnecting fibrous systems have been described. (1) The projection fibers, which connect the cerebrum and the cerebellum with the rest of the brain and with the spinal cord, some of which are afferent (bearing excitations which may originate in the receptors) and others efferent (impulses outward-bound toward muscle and gland, including the great pyramidal tract); (2) association fibers, which connect with each other the various regions of the

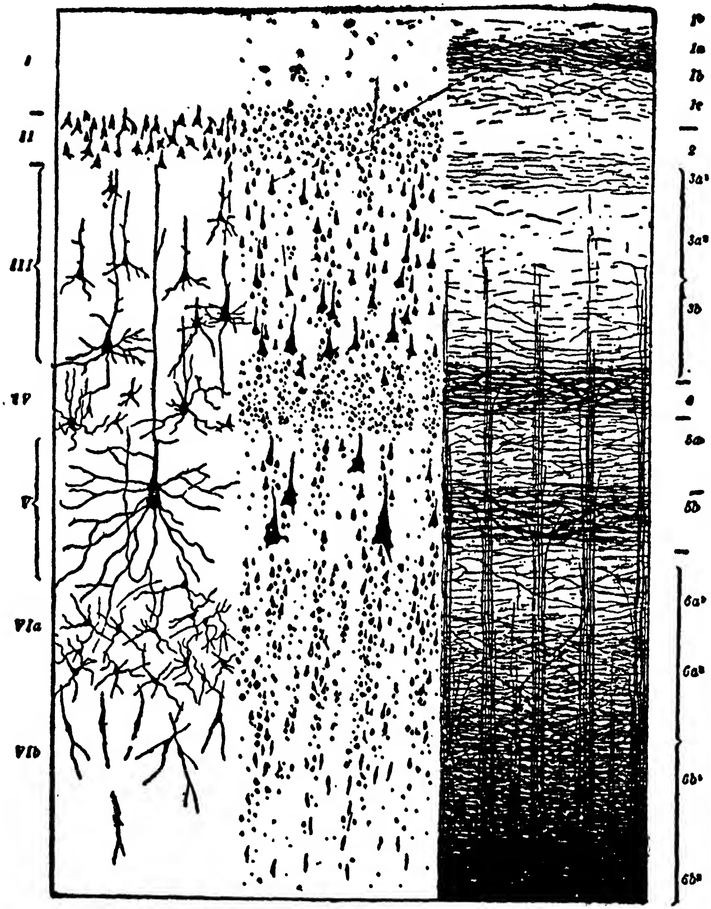


FIG. 27.—ARRANGEMENT OF CELL BODIES AND FIBERS IN ONE REGION OF THE CEREBRAL CORTEX

On the left are two arrangements of cell bodies; on the right is the arrangement of nerve fibers according to Brodmann. [From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)].

cortex; and (3) the commissural fibers, stretching across from one half of the central nervous system (cord, cerebellum and cerebrum) to the other half. Many regional differences in type of neurone and in the successive layers of fibers and cell-body have been made out. One region in the cerebral cortex is shown in Figure 27.

Brodmann, who has mapped the cerebral cortex according to these areas, has observed a general correspondence between them and the regions where the large receptor groups are projected upon the cortex by way of the afferent fiber-systems. This similarity may be made out by comparing Brodmann's

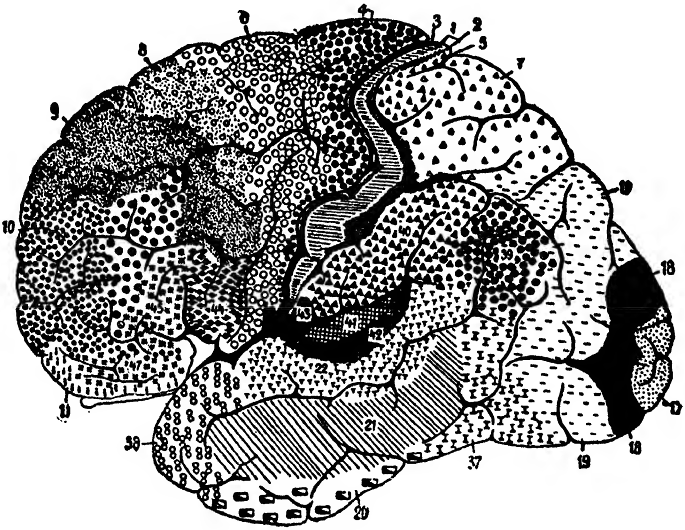


FIG. 28.—MAP OF THE LEFT CORTICAL SURFACE OF THE BRAIN

The regional arrangement of cell-body and process is according to Brodmann. Each area designated by a sign or number has a distinct lamination of its cells and fibers. [From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)].

map (Fig. 28) with the same lateral view of the cortex as laid out to represent the primary stations for these afferent tracts (Fig. 29).

The *visual area* (the cortical termination of the optic tract) lies in the occipital lobes (See *vision* at the occipital or posterior part of the brain in Fig. 29), the *auditory* in the superior temporal, the *tactual* or *somaesthetic* in the post-central

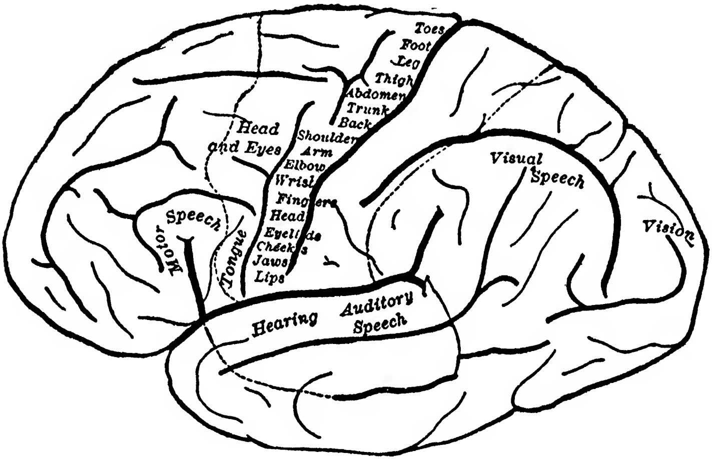


FIG. 29.—FUNCTIONAL AREAS, SENSORY AND MOTOR, LAID OUT UPON THE LEFT SIDE OF THE CEREBRAL CORTEX

[From C. J. Herrick, *An Introduction to Neurology* (W. B. Saunders Company, Philadelphia, 1916)]

gyrus, and the *olfactory* in the hippocampal region. That similar direct connections with the muscles are maintained has been shown by the electrical stimulation of the cortex. When closely circumscribed, stimulation is followed by the contraction of a muscle or a small group of muscles. The chief *motor area* lies just before the great central fissure (the precentral gyrus; area 4, of Brodmann's map in Fig. 28). The

exact topography of this region has been laid out by Sherrington upon the chimpanzee and other apes, and also confirmed by other methods. In the figure on page 116, the words 'toes,' 'foot,' 'leg,' etc., indicate that appropriate electrical stimulation here causes muscular contraction in the parts of the body described.

Now we must not assume that anything like 'consciousness' is lodged in these circumscribed areas, or that one area only is functionating when we visually perceive, another when we listen, another when we visually remember, and so on. While a given projection-area controls the immediate and direct connection with a group of receptors or muscles, the total cortex, which is integrated in a very close way, functionates as a whole, though with focal areas of special emphasis, without doubt, and with a wide variety of functional patterns.

Certain areas within the cerebral cortex are not directly connected either with the afferent fibers or with the great motor outlet in the pre-central region. These areas have been called *association centers;* but numerous attempts to recognize in them the seat of the 'higher mental processes' or of 'association,' taken in the psychological sense, have not succeeded. While they are doubtless of great importance to the functional integrity of the brain and especially to the rapid modification of function involved in the processes of habituation and learning, we have no evidence that they are the specific 'seats' or 'centers' of anything. These areas are relatively larger in the human brain than in any other animal form. It is probable that they are essentially concerned—possibly as focal and integrating areas—in the elaborative and comprehending functions and in certain forms of perception, memory, imagination, and action.

It is obvious that we are still a long way from a satisfactory functional understanding of the brain. The neurologist is just beginning to delve seriously into its metabolism, circulation,

mechanics, and chemistry. Until studies in all these directions have been carried further, we cannot hope to comprehend the activities of this great intricate system of the body. Our present knowledge—and it is compendious and detailed—chiefly touches upon topography, fine anatomy, and conducting and connecting tracts and processes. Comparative neurology has thrown strong light upon the history and development of the nervous system, and pathological states and the mental disorders have given many hints of normal functions. But the real key to the activities of the brain is still to be found. The facts at our command must be illuminated by the newer processes of research hinted at above. Prospects of discovery, however, are very bright for the next decade.

One important element in the solution is a clearer descriptive account of the psychological functions. These operations rest predominantly upon the neural and muscular resources of the body. More accurate knowledge of how the organism works psychologically should re-direct research into the physics, physiology, and chemistry of the body itself. [34]

In the attempt to outline briefly the bodily resources drawn upon in apprehension, we have looked into most of the corners of the nervous system. Were we to make our examination still more complete, we should have also to include the muscular systems and the abdominal and thoracic viscera; for apprehending involves muscular tensions, tendinous strains, poses and postures, as well as the position and state of the visceral organs. These outlying resources will, however, come in for discussion in various other contexts.

The next chapter will show more concretely how the bodily resources just reviewed make their several contributions.

CHAPTER IV

THE PATTERNS OF APPREHENSION

The Perceptive Patterns

Once we know the great variety of receptorial devices of the body and the primary part that these structures play in perceiving, we can easily anticipate that the action of these specialized organs will appear both in the perceptive operations themselves and in their products, *i.e.,* in the perceived objects. As for the perceived objects, the reference to receptors and corresponding qualities is made clear in our common description of these as blue, green, gray, heavy, sweet, sour, high-pitched, sonorous, smooth, prickly, and the like, and of their combination. Every one of these adjectives contains a suggestion of some visual, tactual, gustatory, or other receptor under specific stimulation by a certain energetic agent. The reference from them to the perceptive operation itself is not quite so obvious. To be sure, if we were to call blue, green, pressure, sweet, and the rest 'sensations,' implying that in a certain context they were simple 'processes of the mind' or 'things in consciousness,' the reference would accord with a very old and a very common usage. Since we do not, however, employ those mental terms, the reference must be of a different sort.

The reference must be, of course, to the functional performance of the organism. The point is that in perceiving (and in some other functions) *the function is patterned;* that is to say that the body—notably the receptors, the brain, and the muscles—gives rise to a *qualitative multiplicity.* The light spread in various intensities and wave lengths upon the retina pro-

duces a color-light pattern of visual qualities which begins, runs its course, changes under changes of stimulus and of the visual apparatus, and comes to an end. The only reason why it is not quite easy to regard this changing and fluid pattern as an aspect of the actual functioning is that the pattern so immediately congeals into the permanent product that we more easily consider the blues, grays, etc., as attributes of the colored object itself. Since the interest of the psychologist primarily lies, however, in the performances of the organism and not in colored pictures, savory food, heavy metal masses, and the like, we shall limit our description to the active functional events and to the conditions in the body and in the stimulus which immediately underlie and bring about this sort of perceptive employment. Now that we know something about the receptors and other bodily organs here concerned, we shall have no difficulty in observing these variegated patterns as they arise, and in determining the large part which they play in the operations of a psychological kind. [35]

In order that we shall make no unnecessary mystery of the processes of perception, invoking a kind of magic or miracle which would permit the outside objects to stalk into the avenues of sense and announce themselves in the recesses of the brain, we must observe that the ultimate reason why certain organisms can 'perceive objects and events,' while steam engines, printing presses, radio sets, and other lifeless mechanisms do not and cannot so perceive, is that these organisms are able to repeat, in the fluid processes of their neural and other structures, the properties and energies of detached outside bits of the universe. To the extent to which these properties and energies characterize or duplicate these detached bits or 'objects' is the organism able to apprehend them.

Suppose that an arrangement of lights and colors on the retina or a pressure-pattern on the palm duplicates the form, extent, and surface detail of a hat hanging on a peg or an

orange held in the hand. Certain aspects of the object will concordantly excite receptors in the retina or in the skin. Since the neural impulses here initiated represent the peculiarities of the stimulating object, and since these excitations are severally transmitted to the central nervous system, where they are coherently ordered and integrated, the organism may be said to have imitated, by a sort of mimetic aptitude, properties and agencies resident in the object. But it is important to observe that the outside source of incitement to the body is not an inert mass but a source of energy and that only so does it impress the organism. And just as important is it to consider that the mimetic duplication within the body is not a static and inert copy of something outside but an active process of a physiological sort. In other words, it is an organic event carried out in terms related to, and consonant with, the exciting cause.

Were we to cherish the old notion that the mind sits looking and listening in the brain for 'messages' coming over the nerves, we should be back in the realm of mystery and magic. That is a folk-belief, long encouraged, to be sure, by physicists and some other men of science, that lies beyond the realm of sober description. Once we drop that belief, the problem of getting outside the body and of projecting hence the object disappears. There is no object that is first made up in the head and then, by a miracle of ejection, thrust out into the place where the perceived object lies, to be distinguished, as object, from the perceiving subject. That is a logical and philosophical distinction and not either psychological or physiological.

Another example, chosen from another kind of perceiving, may help to clarify the point about the duplication and the mimetic aptitude of the living organism. Suppose that a simple melody is played upon the piano. The receptors are now acoustical. Many of the hair cells in the organ of Corti are

excited by the first note, others in temporal order by other hair cells (usually with a certain amount of duplication). The neural event accords with what we call the pitch and rhythmic progression of the melody. Receptors, nerves, cord, brain, muscles, and some other bodily structures are adequate for such a representation, in the form of their proper activities. The perceiving is of an object of another order from that of the hat or the orange. It is a melody. Here, as in the other cases, however, the organism performs not only in a physiological way; it performs psychologically, it apprehends things as present and as in process.

So far as our present knowledge of the body and of its activities goes, this is the basis for the sort of apprehending that we are now considering. In our mature perceivings, to be sure, many other devices and many other principles of organic activity come in. We cannot deal with them here, where we mean only to lay the ultimate and primary basis for the apprehending functions. When we go on to describe the changes that the mere exercise of function and the repetition and modification of functional performances bring, we shall find all manner of short-cuts, of simplification, and of elaboration too, which must in time be taken into account for perception as well as for remembering and imagining. We shall find cases (as in the flashing glance at a book or a passing motor-car) where the receptors actually involved account for only a very small part of the perceiving; and we have already noticed that the receptors may pass quite out of primary account in some instances of remembering and anticipating. Once a new sort of function is mastered, the organism finds all sorts of cunning devices for refinement and extension.

The Qualitative Multiplicity

We approach now the study of the great qualitative variety in perceiving which is provided by stimulus and receptor.

The general order will be, first, the visual qualities, then the auditory, and so on.

VISUAL QUALITIES

All visual qualities display a striking kinship, they all belong to one natural class; so we have only to distinguish, to identify, and to arrange them.

First, they fall into two large sub-groups; light qualities and color qualities. The first group contains all the whites, grays, and blacks; the second all that remain, *i.e.*, the yellows, blues, purples, reds, violets, greens, mauves and the rest, of every degree of lightness and darkness, and every degree of richness and poorness. The great delicacy with which the receptors follow differences in the strength of the stimulating light may be gained by the estimation that the grays (or light group) may number almost 1000 distinguishable qualities, when all grades of illumination and all states and tunings of the eye are taken into the reckoning. As for the color qualities, which are set primarily by wave-length and secondarily by light-energy, their number may run beyond 100,000. These incredible capabilities of the visual receptors make a great contribution to the wealth and the variety of our visual perceivings.

The relationships of the *light* group—of 'the gray series' as it is sometimes called—are perfectly simple and unequivocal. If you were to cut out twenty-five small squares of artist's canvas and to cover each with different relative amounts of white and black paint, you would find when you were done that you could arrange these squares in just one way to represent the natural relations of the blacks, whites, and grays which you had painted. This order would give you the whitest white at one end, the blackest black at the other, and the grays (light, medium, and dark) falling between, with

the smallest differences represented by neighboring pairs. This order is the *psychological* order of the light qualities. Within it every quality has its own unique place between its nearest neighbor above and below. [36]

This kind of series is known as a one-dimensional series because it can be represented by a straight line. The ends of the series fall at the two ends of the line and the intermediate qualities fall each at its appropriate place somewhere between.

Whites
Grayish whites
Lightish grays
Middle grays
Darkish grays
Grayish blacks
Blacks

When we turn to the color series we discover that we have not only vastly more qualities to deal with, but that these qualities refuse to be ordered in such a simple manner as the grays or lights. Nevertheless the order is there and we have only to inspect it, as psychologists, to bring it out. Suppose that you were to increase your canvas squares to a hundred and your paints to, say, twenty pigments in oil, well chosen to produce the various colors. If then you sat down for a morning at the fascinating task of painting as many different-appearing squares as you could, you would have at the end a bewildering mass of light and dark, rich and poor, warm and cold colors. Let us assume that the task has been done and set about the arranging of them in psychological order. Select a good strong yellow which is neither inclined toward the olives nor toward the oranges. Similarly select a good strong red which is neither orangish nor purplish. If now you were to lay out these canvas-squares on a gray background you would find that you could select, in the course of an hour, a number of other squares from your morning's painting which would fall naturally between your yellow at the one end and your red at the other, thus giving you the same kind

of one-dimensional series as you produced in the grays. The colors would run as follows:

Y——————————R

A great many reddish, yellowish, and orangish squares you would have rejected simply because they would not easily fit into your series. Some were lightish and washed out, some were darkish and inclined toward gray or black. What you have selected and arranged you may regard as a series of *color-tones* or of *hues.*

Suppose now that you select your richest and strongest green which is neither olive nor bluish and your richest and strongest central blue. You can make up a one-dimensional or linear series, as before, by filling in between the terminal green and the terminal blue. These intermediates will include a number of the bluish greens and of the greenish blues.

Now place the two series near each other and observe them.

Y——————————R

G——————————B

Two facts will at once appear. (1) The upper colors (Y to R) all belong together and all the lower colors (G to B) belong together; but the two series taken as wholes are dissimilar. Our common speech calls the upper series the 'warm' colors and the lower the 'cold.' (2) In spite of this difference in the two branches of the color family, however, it is possible to bridge the gap by putting in a number of olive canvas-squares between Y and G and a number of purple squares between R and B. Now you have a four-sided figure within which

all the hues or color-tones find their place. The figure cannot properly be represented by a circle because the four colors at the corners are real *turning points.* When you set out from the Y-corner and move along the series to the right, you find that you are directly going toward red—not toward the blues or the greens. It would be incorrect, then, to make our figure a circle; for that arrangement would imply that there were no turning points, that the blues were actually anticipated when you set out from the yellow corner toward the reds. They are not. There is nothing in the oranges to suggest an approach to the blues; the suggestion comes only after the *red* corner has been turned. So too the other three sides.

A good many of the colored canvas-squares are still to be disposed of. You decided that they did not fit naturally into the figure of the hues. How are they to be disposed of? Place your color-figure at one end of the table, the light or gray series vertically at the other end, and the left-overs between. As you compare now the left-overs with the two series already finished, you will again be struck by two facts. (1) Certain of the left-overs obviously belong near the center of the table;

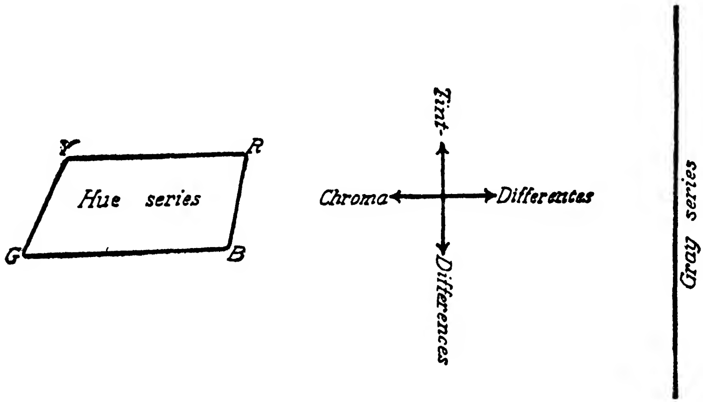


FIG. 30.—LIGHT AND COLOR SERIES

i.e., they have hue or color-tone, but they are also grayish or washed out. They resemble both the color figure and the middle region of the grays. They are color qualities of low *saturation* or low *chroma.* (2) Certain other left-overs are similar to the white and the black ends of the right-hand line, although they do not quite belong in the line because they

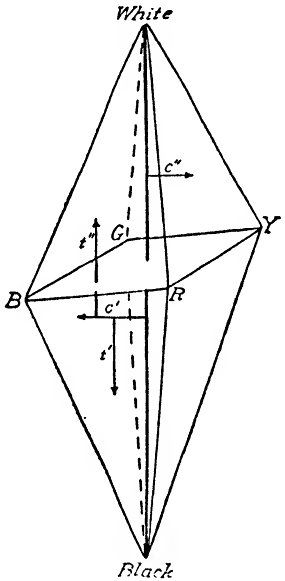


FIG. 31.—COLOR PYRAMID

are 'colors.' They belong intermediately, too, but spread out toward the ends of the black-white series. They are of greater or lesser *brightness* or *tint* than the colors of the four-sided figure at the left.

By this time it will be obvious that all the relations now established cannot well be represented on a flat surface. An arrangement of two dimensions does not show the proper

relations of the hues to the intermediate group and to the grays. This relation is ordinarily represented by a tridimensional or solid figure in which the black-white series is a vertical line piercing the hue-series. This figure is known as the color pyramid. It represents differences of *color-tone* or *hue* upon the lines running about the base, B-G-Y-R; *chroma* or *saturation* differences by horizontal lines, *e.g.*, c', c'', running out from the central axis, and the *tint* or *brightness* differences by vertical lines, *e.g.*, t', t'', drawn parallel to the B-W axis. The figure, then, is solid and each spot within it or on its surface represents some one visual quality either of light or of color. Taken as a whole it represents the entire system of these qualities. It is of the first importance to realize that the pyramid represents only facts and relations of vision and that it makes no reference to pigments, to the properties of the physical spectrum, to the facts of light-mixture, or to the physiological processes in the eye and the brain. [37]

The Relation of Visual Quality to Stimulus and Receptor

When once we have ordered our qualities, many relevant problems arise; problems which have inspired a great number of researches in the psychological laboratories. Most of them relate to the way in which the *qualities depend upon receptor and stimulus, i.e.,* upon the eye and the character of the light which throws the eye into function. We can give only a hint of the nature of these researches.

Visual qualities and the physical properties of light. The most direct way to demonstrate the dependence of color quality upon *wave length* is to observe the solar spectrum, in which sunlight is analyzed into a graded series. What we see is a colored band with reds at one end (the long-wave end) and violet blues at the other (the short-wave end). Although we commonly speak of this array as sevenfold (Sir Isaac Newton's primary colors, red, orange, yellow, green,

blue, indigo, and violet), careful inspection of the series, bit by bit, informs us that several score of unlike but related hues are actually present in the order of the hue series around the color pyramid.

Thus a beautiful parallelism appears between the colors and the composition of the light-stimulus. Not only does the body give rise (as we remarked at the beginning of this chapter) "to a qualitative multiplicity." Within the orderliness of this multiplicity we also see reflected certain regularities of the world outside, to which the perceptive functions are attuned by way of the stimulating energies and the concordant receptors. Near-lying wave lengths produce similar hues (*e.g.*, red and orange, verdigris and Nile green); and distant wave lengths produce dissimilar hues (*e.g.*, red and green, blue and yellow). This parallelism has its limitations, however, as we shall now see.

(1) The physical series we may regard as a continuum stretching, for the average eye under moderate illumination, from about $\lambda = 400$ mμ to about $\lambda = 760$ mμ. We may then regard it as containing as many differences of wave length as we care to deal with. But the difference λ-λ must reach a given magnitude before a hue-difference appears. Very small differences of wave length are said to be 'subliminal' for hue. The total number of hues discriminable under the most favorable conditions within the limits of the visible spectrum is certainly above one hundred. When we make the count we discover further that the value of λ-λ which is just liminal varies from place to place in the spectrum. You can easily demonstrate to yourself that fact by studying an ordinary lithographic reproduction of the solar spectrum. There you will see that hue changes very slowly in the long monotonous stretches of red and very rapidly in the greenish yellows.

(2) In such a study of the solar spectrum you will also

discover that the purple hues are absent; all those hues which lie approximately between the color of a ripe cherry, on the red side, and the lilac blossom, on the blue. These hues are just as real as the spectral hues and every bit as elementary and simple. Were we to supply them (*e.g.*, by way of pigments) a further important detail of parallelism would appear. You now would have recovered the complete base of the color pyramid; four series represented by the closed figure of four lines and four turning points. [38]

The psychologist's spectrum (as it is actually made up in demonstrational form in the writer's laboratory) would represent these four series in natural order with a like rate of hue-change running all the way around. The fact that we see cerise, mauve, lilac, and the other purples proves that some form of stimulus besides *simple wave length* suffices to stimulate the eye. And if we were to throw upon a single spot in the retina (as by a pair of mirrors) a ray of 'blue' light (*e.g.*, $\lambda = 470$) and a ray of 'red' light (*e.g.*, $\lambda = 670$), we should actually produce one of the missing purples. Light-mixture, then, is a factor. It may also be a factor in producing the 'spectral' colors, as your recollections of the child's set of pigments will convince you. (3) The whole problem of *color mixture*, of the dependence of gray and color quality upon the *composition* of the stimulus-light, thus confronts us. Fortunately for our exposition, simple uniformities have been worked out. There is one 'law' for hue, another for chroma, and a third for tint. For the psychologist they are most appropriately expressed in terms of *component* qualities (qualities whose stimuli are to be 'mixed' or compounded) and *resultant* qualities (the outcome of the 'mixture').

The laws run as follows. In reading them it is of the greatest importance to realize that the *physical lights* are *mixed* or the *pigments* are *mixed;* never the color and light qualities, the qualities of perception itself.

I. *Resultant hues* lie between the hues of the component colors and nearer the stronger component.

II. *Resultant tints* lie between the tints of the component colors or grays and nearer the stronger component.

III. *Resultant chromas* (a) range between zero (for gray resultants) and the chromas of the components; and (b) they vary directly with the component chromas and inversely with the qualitative remoteness of the component hues.

For the application of these laws it is not necessary that the component colors should have been produced by 'unmixed' or homogeneous lights. The laws may be demonstrated as well by colored papers and transparent glasses, which give exceedingly complex lights, as by filters or by monochromatic strips from the solar spectrum. We may therefore add to our three specific laws a fourth, of more general import. It runs as follows:

IV. The mixing value of a physical light which produces a given gray or color is (under constant illumination) independent of its composition.

Central and peripheral vision. Were you to cover one eye and to stare fixedly with the other at a spot upon the opposite wall while an assistant slowly carried a bit of brilliant red paper or cloth from the neighborhood of the fixated spot to the right or left until you could no longer view it, the red would undergo qualitative changes. If it were a slightly orange red it would grow yellower and at a later time it would change to a gray. Nearly all colored lights give rise to these changes of quality. So we discover that the actual visual quality which appears from a given stimulus depends in part upon the area of the retina to which the light-stimulus is applied. At the outer rim or zone of the retina all lights produce

(except under certain unusual conditions) only grays. An intermediate region gives rise to certain color qualities but not to others. As this region is poor in red and green vision, it has been called the yellow-blue zone. Finally, light cast upon and around the fovea (the area of clearest vision at the center of the retina) gives rise to all the qualities found in the color pyramid. These inequalities are indicative of widely differing degrees of sensitivity in the various regions of the retina. Not only is there one central area (the fovea) of very limited extent which is best equipped with receptors (cones) fitted for 'clear vision,' in the sense of sharpness of details of form, contour, size, etc.: there is also one central region (considerably larger than the fovea) where all the color qualities and all the light qualities may be initiated by the proper means of stimulation. Such an animal as the white rat, which has no structural fovea and probably no receptors which are specifically tuned to the frequency or wave length of light, is far more limited in its perceptive range than we are. [39]

Adequate and defective color systems. The poverty of color from the outermost zone of the eye reminds us that some persons (at least one or two in a hundred of our male population) are blind to certain colors no matter where the light falls. The commonest form is *red-green blindness,* so named because the reds and greens are seen as grays or grayish yellows and grayish blues and so confused. This defect is usually congenital and it does not then denote any diseased or pathological affection. The color pyramid of the red-green blind is what you would see on the exposed surface if you were to cut the pyramid across diagonally from the Y to the B corner. Yellow and blue would be present at all degrees of tint and of chroma; but R and G would be lacking as well as the qualities along the R-Y and the G-B lines. Occasionally, in *total color blindness,* all colors are wanting. The pyramid

is, therefore, reduced to the bare black-white axis. There are also many special or *anomalous* cases of color defect.

A curious detail in the construction of the eye leaves an area which is totally or practically blind (blind spot) where the optic nerve pierces the retina from behind on its way from the brain. Here the nerve-fibers spread out over the retina from this blind center, where no receptor organs exist. If you will close and bandage one eye, stare fixedly at a spot on the wall with the other eye, and pass a quarter-dollar back and forth from left to right at arm's length before your face, you will be surprised to discover how far the coin will move quite unobserved, as the light rays from it pass over the blind spot. We ordinarily neglect this blank area in our perceptive field. The fact that the two blind spots of the two eyes fall at different places in binocular vision is of some aid; but the general disregard of the area in monocular vision, too, shows how small a part it plays in our perception of objects and movements.

Dependence of visual quality upon spatial pattern and sequence of stimulus. Every one has seen the blue-gray shadows cast against snow under the yellowish light of a late afternoon in winter. This phenomenon, when translated into terms of retinal stimulation, reads: a bit of 'gray' (white-light) stimulus set close beside a 'yellow' stimulus gives the appearance of blue. This is known as *simultaneous contrast.* At the same time, the stimulus also effects a *direct* change in the function of the receptors. Excitation gradually declines under the action of the stimulus. This change is called *adaptation.* On the side of visual quality it means a reduction of chroma toward the axis of the pyramid and a shift throughout the gray-series toward a middle gray. It is clear, therefore, that adaptation, if it were to proceed from all directions at once, would shrink the pyramid to a single small area near the center of the gray axis.

That this reduction does not actually take place is due to a second temporal effect of the stimulus. Not only does adaptation mean a dulling of a particular region in the color system; it means also an opposite effect in another, 'complementary' region. Adaptation to green lights increases the sensitivity to reds; adaptation to yellows increases the blues, and so on for every hue-region. After exposure to green, then, a neutral gray tends to appear red, after exposure to yellow the same gray surface appears bluish.

If the light stimulus is local, its removal leads to the *after image;* if it is general, the whole visual field is *tuned* toward the complementary color. Thus we are tuned by the predominant green lights of the summer foliage and tuned again by the high white light reflected by the snows of winter. Thus we are more or less permanently 'red-sighted' in summer and 'dark-sighted' in winter. Thus the eye is nearly always biased toward certain regions in the color pyramid and away from others. The color perceived at any given moment is a function, therefore, of the state of the retina as well as of the stimulating lights. In predicting what color will be perceived we may then employ the principles of components and resultants just as we have in color mixture. The effect of time, therefore, is to produce reciprocal or compensating effects; as if you were to drop one end of a balanced board downward and thereby to bring the other end upward. Stimulus dulls vision (chroma-wise) on one side and sharpens it on another.

The direct effect of contrast is to sharpen boundaries. When black is next to white it appears blacker and the white appears whiter. The direct effect of adaptation, on the other side, is, since it brings a reduction of chroma, to soften and to obscure differences.

Twilight vision. When the light stimulus is greatly reduced in energy, a notable change appears in our visual system. Vision in weak light (as with oncoming darkness) is known

as *twilight vision.* We may compare it with *daylight vision* in terms of the pyramid. Very weak light gives rise to light qualities (the grays) but not to color qualities, and the exact point where hue and (of course) chroma disappear depends both upon wave length and upon the retinal area affected. It is obvious that in very deep twilight the landscape will be colorless. As in total color blindness, the pyramid is therefore reduced to the black-white axis. But this loss of color is not abrupt. As we all know, at the decline of the day woods and fields not only grow dark; they also grow somber; the colors are dulled; the chromas are reduced. At this intermediate point a curious thing happens. The red hues lose in chroma and in tint much more rapidly than the blues. You can verify this fact by choosing a red and a blue pencil, candle, or sealing stick, of about the same tint and richness in color, and by carrying them into an almost lightless room. Under dark adaptation the blue becomes *relatively* richer, the red going off into a very dull blackish red. That the entire series of hues suffers under this change is shown by observing the whole solar spectrum in dark-adapted half-twilight vision. The red end grows a dull reddish black; the maximal tint shifts from yellow toward green, and the blues glow with relatively high tint and great chroma. This half-twilight shift is known (after the Austrian physiologist who described it) as the *Purkinje phenomenon,* and the shifted spectrum as the *Purkinje spectrum.*

Described in terms of the pyramid, this half-twilight vision means a deep paring off of the outside of the figure, bringing all the sides and corners near the axis (absolutely low chromas), a cutting off of the white top (absolutely low tints), a lowering of the R-corner, a crumpling down of the Y-corner, and a relative elevation of the Y-G, G and B areas (relative shift in tint). The blue corner stands out a little further than the red (relative shift in chroma). Since the

equator has been greatly decreased in girth (all the high chromas having disappeared), the total number of hue differences is of course enormously reduced.

Taking together these five topics, which relate the visual qualities to stimulus and to receptor, two or three significant generalizations appear. (1) When we speak of 'a system of visual qualities' we refer to the sum-total of qualities derived under many conditions. We must remember that this totality is variously reduced and modified by (a) the wave length and the energy of the light, (b) the retinal region stimulated, (c) the adequacy and inadequacy (color blindness) of the eye to color excitations, and (d) the spatial and temporal relations of stimuli. Here we have only touched upon the most outstanding of the relations and the dependencies of vision. The facts from which an exceedingly large and involved experimental literature has grown have had to take into account the wide variability of stimulus, the great complexity of the ocular receptors, the close functional relation to the brain (of which the retina is a direct outgrowth), and, finally, the vast number of visual qualities themselves, each of them ultimate and simple and all set into a compact and articulate system.

If you will return now, with your new knowledge about vision, to the description of the receptors in Chapter iii,—to the rods and the cones, with their unlike functions and their uneven distribution over the retina—you will see that much light has been thrown upon the bodily resources by the facts just now related about the visual qualities. Where these psychological facts outrun our physiological knowledge we set up the hypothesis of three mechanisms (a red-green, a blue-yellow, and a white-black), each the seat of two antagonistic processes. The series of hues is then referable to the interaction of these mechanisms, under the action of light stimuli, and so are the facts of light-mixture, as formulated in the laws above. Adaptation is accounted for by the obvious decline of

the receptor processes as stimulation goes on from moment to moment; and the observed facts of light-contrast and color-contrast are accounted for by the spatial interaction of adjacent stimulated areas. While any single area of the retina is responsive to its own direct stimulus, it is also influenced by the photochemical and neural processes proceeding in other parts of the entire organ.

Two general views have been held respecting the relations, under the action of light waves, of the receptors to the brain. The one view holds that the receptor essentially initiates and controls what is subsequently to happen on the upper levels of the brain. There is here supposed to be a sort of central duplication of the receptorial functions. The other view regards the cortex of the brain as itself initiatory and controlling. This is sometimes called the 'central dynamic' view. Here the brain is regarded as the seat of tensions and strains which have a tendency, when left to themselves, to establish an equilibrium. This equilibrium is, however, constantly disturbed by neural discharges which come from the receptors. The patterns of perceptive apprehension are, therefore, on this second view, representative of the struggle toward equilibrium in the 'brain field' when this field has been disturbed from these peripheral outposts.

The views differ in emphasis among the bodily resources in apprehension. The one tends to exalt the receptor and its stimulus: the other sets its primary emphasis upon the nature of those integrated energies (of a chemical and electrical sort) which are assumed to be constantly established and modified in the brain. The new method of amplifying and recording the electric potentials in the brain, the receptors, the nerves, and also in the muscles, promises to throw light in time upon precisely this point of the exact manner in which the entire apparatus operates to support the apprehending functions which are our special concern in these chapters. [40].

AUDITORY QUALITIES

In their common descriptions of the raw materials of hearing, men roughly distinguish tones, noises, and vocal sounds. These classes correspond in a general way to the three great sources from which our auditory perceptions spring. Thus we speak of the 'tones' of music, the 'noises' of nature and of the street, and the 'sounds' of the human voice. Since our concern now is with auditory perception on its qualitative side only and not with the *outside sources* of it, we can scarcely set out by uncritically adopting such a classification, useful though it is in our common speech. We cannot adopt it without modification if only because the musical instruments produce mixtures of what are psychologically simple tones with various noisy components. Thus the note which is produced by striking a piano key, bowing a violin string, or blowing on the cornet, is a whole series of tones (fundamental and overtones) together with the noisy thump, scratch, or hiss which helps to characterize what men loosely call the tone. Likewise the noises of nature and of the street are medleys of simple tones and noises, as are also most of the vocal sounds produced when air passes through the larynx and in and out of the mouth while we speak, whisper, or sing. But while we make these modifications, we shall nevertheless find that *tone, noise,* and *vocal sound* play a very large part in the psychology of those perceivings which are built around the functions of the ear.

The best way to get rid of all outside associations and prepossessions is to sit with eyes closed while an assistant at the back of the observer quietly and repeatedly taps with a light rubber hammer upon a tuning fork. The tuning fork is simply a rigid and elastic pendulum wagging wrong-side up. Its regular 'pendular' movements give rise (when the fork is carefully operated) to a simple and prolonged auditory quality.

The problem is to discover by a direct observation what the quality actually is. In the psychological laboratories throughout the world not only one but thousands of such qualities have been observed and compared. Our description will follow these observations.

First, it appears that all these *tonal qualities* belong to one continuous system. In this respect they are like the members of the gray series which extend from the first black to the last

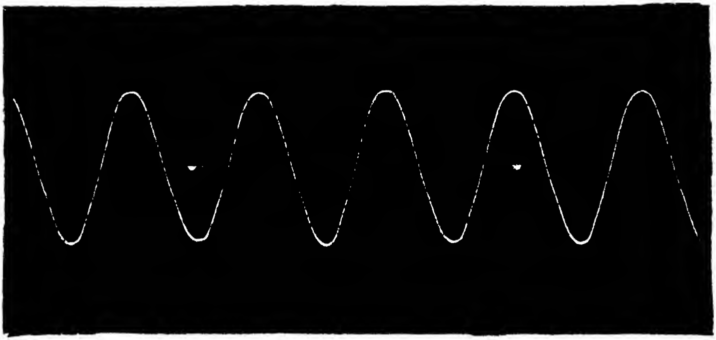


FIG. 32.—ENLARGED REPRESENTATION OF THE MOVEMENT OF A TUNING FORK WHEN PRODUCING A SIMPLE TONE

This curve is made when one end of the vibrating tuning fork is allowed to rest on a sheet of blackened paper moving at a steady rate. [From D. C. Miller, *The Science of Musical Sounds* (The Macmillan Company, New York, 1916)].

white. The most obvious aspect of the tonal qualities is *pitch*. The tones in the series continuously rise, as we say, from low to high. In the entire series more than 10,000 separate qualities can be distinguished. But 'highness' and 'lowness' do not exhaustively describe these tones. The low tones are also 'massive,' 'diffuse,' 'voluminous,' and the high tones are 'contracted,' 'small,' and 'sharp.' It has been found that this difference in *diffuseness* or *volume* is inherent in the tone

itself. There is experimental evidence to show that *volume* is an aspect different from pitch.

But the qualitative character of the simplest tonal experience is not yet exhausted. Tones are also *dull* and *bright;* the low tones being dull and the high tones bright. The course of brightness throughout the tonal series has not been adequately studied; but preliminary explorations suggest that brightness-change may go on, from below upward, precisely with pitch-change, the point or span of change from one to its nearest neighbor being the same for both. A complete account of the tonal quality, then, includes its *pitch, volume,* and *brightness* aspects, which suggest color-quality with its hue, tint, and chroma. But there is a difference. An appropriate section of the color pyramid shows hundreds of qualities possessed of one hue at all chromas and all tints (*e.g.,* a vertical section through the R-corner to the axis). One R-hue alone is here exposed. A given pitch, on the other hand, does not, so far as we know, thus display a series of brightnesses and a series of volumes. For this reason it is difficult to represent in any spatial figure the qualitative series of tones. The proposal to use a 'tonal pencil,' sharp at one end and flaring at the other, the lengthwise dimension to represent pitch and the diminishing cross-section the decreasing volume, ignores this fundamental difference in the facts of visual and tonal apprehension. Since pitch dominates the tone, making up, so to say, the *salient* aspect of it, it will be simplest to regard the tonal series as a continuous series, the members of which are distinguished by the three moments, PITCH, volume, and brightness.

This qualitative description seems to offer a basis for musical sounds; but what shall we say of speech or of noise? Since speech is complex, we must first reduce it to its phonetic constituents, which are roughly divisible into vowel-sounds and consonant-sounds. Now a vowel-sound bears an obvious

relation to a single tone, though it is complex where a tone is simple. It is more like the tonal complex in the musical note. When we run through the series *u* (moot), *o* (mote), *a* (art), *e* (ate), and *i* (bee), we soon discover a pitch progression, a diminution in volume, and an increasing brightness. But when we try to identify each vowel with one particular tone (as in a tuning-fork series) or even with a whole series (with fundamental and overtones) we fail to discover identity. No vowel is exactly the same as any single tonal pitch or a combination of simple tones. [41]

Now what *is* the character which makes the vowel-sound unique? In the first place, the essential part of the vowel-sound, the formant, *appears to correspond to a tonal region* and not to a single vibration rate. In its qualitative nature it is wanting in the salient 'pitch' aspect. It is instead a dull, soft, obscurely pitched accompaniment to the fundamental tone upon which the vocalic sound is based. Here, then, the aspect of brightness seems to usurp the place of pitch and to give a characteristic coloring to the sound. We might, then, indicate its qualitative formula as pitch, volume, BRIGHTNESS. Its function in the vocalic sound is believed to depend in part upon the clearness of the fundamental and the obscurity of the formant, because attention directed to the formant itself tends to destroy the vowel-character or vocality of the sound. On the side of stimulus, the obscuring of pitch and the salience of brightness may be dependent upon a long crest and a low trough of the sound-wave. [42]

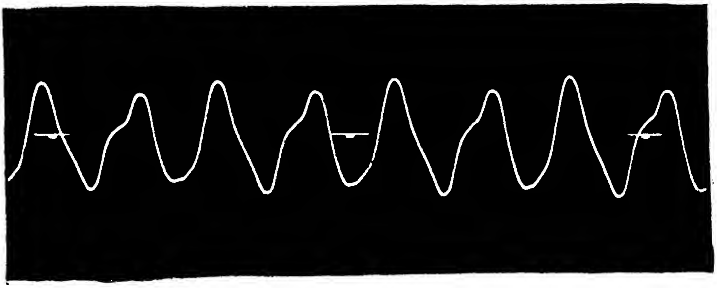
The careful analysis of vocal sounds and the synthesis of them by means of rotating discs, cut in the form of the sound wave and set to influence the delicate photoelectric lamp, have both failed to solve wholly the enigma of the characteristic vowel-sounds. It is just possible that the element of time will have to be taken into account; that it is the way in which the wave-form changes as an 'ah' or 'ow' or 'oo' is running its

course that adds a peculiar vocalic coloring to something which might otherwise have been a musical sound or note.

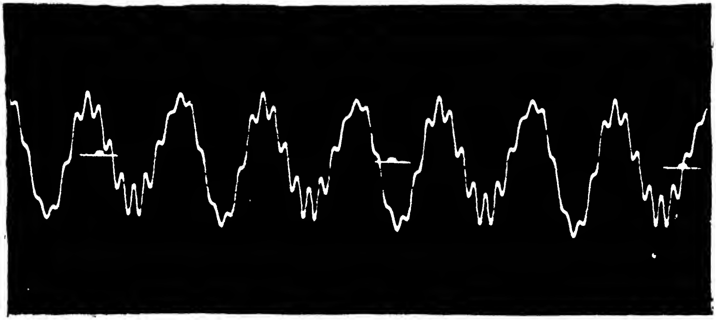
As for the noises, it is not difficult to discover evidences of the close qualitative affiliation of these sounds with tones. A small stick dropped upon the floor gives a characteristic sharp, clean noise; but if we cut a dozen sticks to appropriate dimensions and drop them in order, something very like a tonal sequence emerges. In fact, one musical instrument, the xylophone, produces sounds of just this noisy character and still may be roughly tuned to the musical scale and made to play melodies. Again, very high and very low tones are distinctly noisy, and even within the middle range the drum and the cymbals thump and clash, while ten adjacent keys struck together upon the piano produce a sound more thunderously noisy than musical. But all of these sounds are obviously complex, and if we are to compare them with tones, we must, of course, reduce them, as we did the vowels, to their lowest terms. Toward this end, the psychologist has received but little aid from the physical acoustician, who is generally content to describe a noise either as an imperfect tone or as an aperiodic vibrational movement. So far as the experimental evidence goes, however, the simple noise appears as an auditory quality whose pitch component is more like the formant than like tone and whose brightness is characteristically rough.

The formant in the vocalic complex would seem to stand as an intermediate between tone-quality, on the one side, and noise-quality, on the other. It is almost certain, however, that most of our noises are rough complexes whose total qualitative character is determined by varying degrees of pitch salience, volume, and brightness. If we leave these complex qualities out of account here, we may summarize our discussion by saying that all the simple auditory qualities possess the attributes of pitch, volume, and brightness. In *tone* pitch is clear-cut, obtrusive and dominant, and its changes coincide

with the changes of brightness. In the *formant* (the characteristic part of the simpler vocal sounds) pitch is no longer the salient attribute. Brightness here dominates, the formant contributing a shading or vocalic character to the fundamental



The vowel *oo* as in "room"



The vowel *ee* as in "bee"

FIG. 33

[From R. M. Ogden, *Hearing* (Harcourt, Brace and Company, New York, 1924)]

and other tones. In the simple *noise,* finally, pitch is still more obscure than in the formant. It resembles a whole region of tonal pitches without coinciding with any single one. Thus we know that distant thunder is lower in pitch than the crack of the rifle and this in turn lower than the pop of a soap

bubble or the hiss of escaping steam; but no one of these noises coincides with a single pitch-position in the tonal scale. More characteristic of the noise is the variable brightness and possibly also an added attribute of roughness. [43]

Beats

When two tones whose vibrational rates are almost coincident—say 300 and 303 vibrations—sound together, a strange slow throbbing is heard. When examined this throbbing is found to consist of a regular alternation of intensity—weak, strong; weak, strong; etc.—of a single tone. When these two

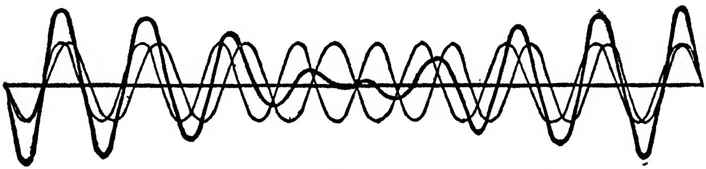


Fig. 34.—Wave-trains Underlying Beats
[From R. M. Ogden, *Hearing* (Harcourt, Brace and Company, New York, 1924)]

rates are separately sounded, one after the other, they are observed to be of different pitch; but the selfsame stimuli given together to the ear arouse only one quality and that quality at a variable intensity. The energy-changes in the stimulus are represented in Figure 34. The light lines represent the two rates and the heavy line the algebraical summation of them. The flat place at the center is due to opposition in phase of the two wave-trains. It is at this point that the tone becomes weakest.

With a greater difference in vibrational rate (and therefore with a greater qualitative disparity of the tones) the two primary qualities reappear; and, in addition, a third rough, noisy, beating tone, intermediately placed, comes in. At a still greater separation, the middle tone disappears leaving only

the two primaries, but these now rough and noisy. The latter phases are of especial interest to the psychologist, first because they afford an instance of noise with two simple and periodic tonal rates, and secondly because the noise quality slips in as by stealth when the intensive alternations gradually increase.

Difference Tones

As the beats disappear, owing to the spread of the rates of physical vibration, a new phenomenon appears. It is the difference tone, which corresponds (in its simplest case) to the difference in the two rates. Thus when the tone $C_6 = 2048$ and $D_6 = 2304$ sound together, there is added the tone $C_3 = 256$ $(2304 - 2048 = 256)$. There is a strong tendency to localize it in the ear. In most cases the physicist is unable to discover such a component in his compound wave-train; so it is probably necessary to refer it to the functions of the ear. These difference tones are ordinary tonal qualities bearing no mark of their strange bodily origin. But they play an important part in speech, song, and instrumental music.

TASTE AND SMELL QUALITIES

The close alliance in daily life of taste and smell, of the 'chemical senses' as they are called, suggests an important fact. The receptor organs for both stand guard together at the gateway to the digestive tract. As they are alike thrown into function by edible substances taken into the mouth, it is natural that they should make joint contributions to the flavor and the savor of food. But where we commonly speak of taste or flavor the psychologist distinguishes gustatory qualities (taste proper) and, in addition, olfactory qualities (smell proper), as well as cold, warmth, pressure, burn, and other 'non-chemical' ingredients. Smell has the advantage of a distance receptor, for it is often excited by diffused chemical sub-

stances borne in minute quantities through the air to the nose; and when the olfactory qualities are thus produced without direct contact of the odorous mass with the body we have no difficulty in recognizing the odors as characteristic and independent perceptions. On the other side, we have only to confine the stimulus to the tongue, by stopping the nasal air-passages, and then to eliminate pressure, temperature, and the other extraneous qualities, to realize that taste also is unique and not to be confused with smell or with any other sense. [44]

In arriving at the *taste qualities* the psychologist has first, of course, to cast aside all object-names, such as the taste of wine,

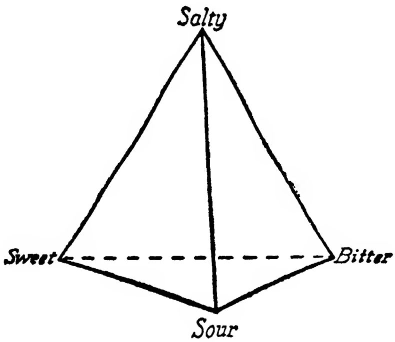


FIG. 35.—TASTE TETRAHEDRON

of sweetmeats, of flesh, and of vegetables, and to accept only such underived and unmixed qualities as actually appear with the excitation of the taste receptors, without regard to the chemical or the dietetic nature of the stimulating substance. The qualities so derived have been gradually reduced to four —bitter, sweet, sour (or acid) and salt. Upon these four experimental research is generally agreed. There is agreement, too, upon the fact that taste mixtures or blends also occur. Thus sweet and sour both contribute to the taste of lemonade,

and bitter, sour and sweet to the flavor of the ripe peach. But the existence of simple intermediates between our four qualities is another question.

Is there, for example, a single new gustatory quality that stands related, on the one hand, to sweet and, on the other, to salt? Kiesow, an indefatigable student of taste, has maintained that there is and that it is to be described as the vapid, insipid, or flat quality. The simplicity of this taste has been questioned; but other intermediates have lately been alleged, intermediates which stand to two of our four 'corner' tastes much as the orange hues stand to red and yellow and the purples to red and blue. Thus Henning puts baking soda and ammonium chloride between salt and sour, sugar of lead between sweet and sour, acetone between sweet and bitter, bromide and iodide of potassium between salt and bitter, alkaline between sweet and salt, and sulphate of potassium between sour and bitter.

Whether a complete set of these gradations exists, to be represented by straight lines connecting salt and sweet, bitter and sour, etc., we do not know; but the facts at hand are best represented for the time being by the taste tetrahedron, proposed by Henning, and represented in Figure 35. If the graded series are complete, then we should have all the simple qualities represented along the six edges of the figure with salty at the apex and sweet, sour, and bitter at the three corners of the base.

In comparing the taste tetrahedron with the color pyramid, we note in tastes (1) nothing like a *neutral* axis to which all color qualities stand definitely related, (2) no reference at all to the interior, all the taste qualities being confined to the surface of the figure, and (3) no independent variation—so far as we know—of such general attributes as hue, tint, and chroma.

The comparison with vision leads us to ask whether tastes

likewise display compensation or antagonism, two opposite tastes destroying one another; and whether, again, one taste may enhance another by contrast. Evidence of both appears in daily life. We mask the bitterness of coffee with sugar (compensation), and we pucker at the enhanced sourness of grapefruit taken after sweets contrast). Of course, these are not pure gustatory cases, for many other qualities enter; but experiment has confirmed them to some extent. [45]

The stimulation of the taste receptors is plainly of a chemical nature. Our knowledge of the chemical difference underlying even the four corner tastes is far from complete; but we may say with some assurance that the *sour* quality is (at least generally) due to hydrogen ions; *salt* to the ions (anions) of chlorine, bromine, iodine, and some other substances; *bitter* to ions (cations) and, especially in morphine, quinine, strychnine and other alkaloids, to certain atomic groups of which the nitro group NO_2 seems to be best recognized; and *sweet* to certain atomic groups, notable in some of the alcohols and sugars, whose character and activity are not fully known.

When we turn to *smell* we find our task enormously increased. Because the olfactory qualities are unnumbered, if not innumerable, it is only within the last decade that we have had a classification and description of the qualities at all comparable with the other senses. The fact that most of our names for odors are borrowed from objects and chemicals (*e.g.,* rose, violet, heliotrope, camphor, onion, rubber, vanillin, chlorine, ether, etc.) suggests the difficulty of divorcing the odors themselves from their multitudinous sources and of reducing them to order. Linnaeus distinguished nine gross classes which the Dutch physiologist Zwaardemaker introduced in modified form to the psychological literature of smell. Although Zwaardemaker greatly advanced our knowledge of olfaction, his classes are but a first approximation to an orderly account. In 1916 Hans Henning proposed

a thorough revision of this classification by making a direct comparison of hundreds of smells chosen from a large number of sources. Thus he would compare camphor with menthol or vanillin, burnt wool with iodine, and so on. As a result of his investigation he proposes the *olfactory prism* (Fig. 36) with six 'corner' odors which occupy a position in the whole qualitative system somewhat analogous to our R, Y, G and B

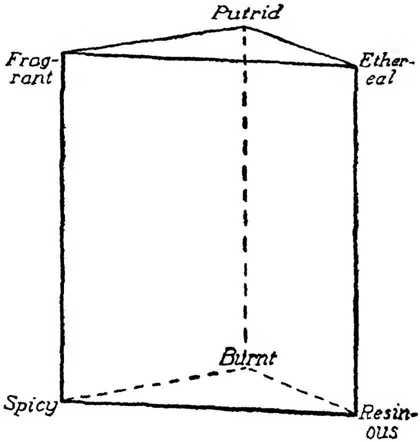


FIG. 36.—HENNING'S OLFACTORY PRISM

corners in the visual system and to the four corners of the taste tetrahedron. The six names at the corners do not stand, however, for six qualities alone. They indicate, instead, six classes which are interconnected along the lines of the prism. Thus between the two left-hand corners stand the fragrant-spicy odors, as simple as the corner qualities but having a double aspect (as the orange colors have), a likeness to fragrant and a likeness to spicy. This relation holds, at least theoretically, for all nine edges of the figure, and upon the faces we have other simple qualities sustaining more complex

relations with the corners. As Henning believes, then, all the simple odorous qualities belong to a single articulated system whose members and relations may be represented upon the surface of the prismatic figure. The space within (departing again from the order of the visual pyramid) is reserved for an indefinite number of mixtures or smell-complexes. Each simple quality is produced, as Henning contends, by a given chemical substance and cannot be exactly reproduced by a mixture of any other substances.

Many attempts have been made to solve the chemical riddle of smell; to determine the constitution of odorous substances. The facts are obviously complicated. Nothing corresponding to wave length and light composition has been made out. Henning's own attempt, which rests upon the mode of connection of certain atomic groups and radicals within the benzene ring, is directed toward the explanation of his own six qualitative classes. The scheme is certainly not usable without modification. It is possible that it may be made more intelligible when the qualitative system of six classes, which is by no means final, has been sufficiently revised. Parker's inclination to work out the chemistry of olfactory stimulation on the principle of separate components and to persuade the qualitative classification to conform to the results is no more to be commended here than in taste, audition and vision. To posit conditions without a descriptive knowledge of the experimental facts conditioned is to make a logically wrong beginning.

Henning's six-fold classification is the first concrete and thorough-going attempt to isolate the olfactory phenomena from everything else, and to establish by direct comparison exact qualitative likenesses and differences. His results are far too few and many of them too uncertain to establish a definitive system; but they furnish a basis upon which to work. Already have they suggested more rigorous methods of ex-

perimentation. Henning has insisted on a rejection of all non-odorous qualities; and it seems likely that this refinement in method and in observation must be carried still further before our classification can be made complete and final. Inhalation itself, when pronounced, sets up a dry pressure in the nose, and, again, many substances are irritant (attacking the trigeminus nerve) as well as olfactive. Moreover, attentive perception to smell is likely, except under the most rigorous training, to mean 'attention to the nose' or 'attention to inhalation.' In making olfactory comparisons on the basis of quality alone, the present writer has found that smell itself is frequently—and possibly always—non-localized. Nowhere else, so far as he knows, does the observer report qualities so utterly divorced from spatial and other objective adhesions as in smell.

SOMAESTHETIC QUALITIES

According to the tradition which ascribes to man only five senses, touch alone remains for our description. But here tradition cannot be sustained. Instead of a 'fifth sense' experiment discloses long lists of qualities deriving from many receptors and exhibiting various degrees of family resemblance. One such list might include *pressure, pain, warmth,* and *cold,* to mention only those qualities obtained by simple stimulation of the surface of the skin; and further experimentation reveals that each of these qualities may be elicited only from small isolated areas. The skin is not uniformly sensitive to any type of stimulation but proves to be a mosaic of minute areas of special sensitivity, whose size may be inferred from the fact that well over a hundred of them are often found in a square centimeter of skin. (Thus an average square centimeter of skin contains approximately 100 points at which pain may be elicited, 25 such points for pressure, possibly 10-12 each for cold and warmth). For any single area examined the

relative numbers may fall out quite unlike these rough averages. The same qualities may be obtained by stimulation of the linings of the mouth, pharynx and esophagus, as well as from certain abdominal viscera under conditions of artificial stimulation. [46]

The psychologist's knowledge of the perception of internal states is incomplete. Most of the examinations of visceral qualities have been made under artificial insult to the inner organs, *e.g.*, the pressure balloon to the stomach and the electric current to the walls of the esophagus. But these alimentary regions and organs are normally the seat of digestive, secretory and peristaltic processes which may color our perceptions and emotions in a way not realized by outside stimuli. In digestive disturbances we find, to be sure, our pressures, pains, and temperatures; but it looks as if these three might not exhaust the list of qualities normally evoked from the viscera.

Pressure exhibits at least two qualitative shadings. *Contact* is an instable, diffuse quality which sometimes arises under light mechanical stimulation; and when a dull point is brought against the skin, a firm, condensed, *solid pressure* may appear. *Tickle,* which has sometimes been regarded as a unique quality, now appears to be fairly complex and to involve no new qualitative component, being closely related to pressure. Because of the great sensitivity to small vibrations at very high rates of speed, one psychologist has actually proposed a separate 'sense of vibration,' but this has not met with general acceptance.

Cold has never been subjected to adequate experimental scrutiny, but preliminary work suggests that it may exhibit such shadings as *cool, cold,* and *burning cold.* There have been many more researches upon the upper end of the scale of sensitivity to temperature, and these have differentiated such qualities as *warmth, heat* and *burn.* All of these are simple perceptual qualities, but it must be noted that the latter

two are evoked by complex stimulation, *heat* coming from simultaneous stimulation of warm and cold receptors, and *burn* from simultaneous stimulation of warm, cold and pain receptors.

Pain has been diligently studied; but the shadings proposed for it lack conclusiveness. Such epithets as 'stabbing,' 'cutting,' 'stinging,' 'aching,' and 'tearing' have been suggested; but most of these terms relate to the damage wrought upon the organism by the painful instrument or object. Apart from intensive differences, there are, it appears, very few qualitative shadings of the pain quality, and the descriptions of these shadings are still unsatisfactory.

Stimulation of receptors in the muscles, joints, and tendons arouses a variety of qualities which may be separated experimentally and which must be considered in isolation from one another. Contraction of, or pressure upon, the muscular tissues produces a characteristic *dull* (*muscular*) *pressure;* intensive stimulation of these tissues may produce *pain,* while long-continued stimulation produces *ache.* Receptor organs upon or near the bony surfaces of the joints appear to be responsible for *articular pressure,* distinguished with difficulty from the cutaneous quality.

Closely associated with these qualities in our perception of movement, but easily distinguishable from them upon observation, is *tendinous strain,* so called because its receptors are in the tissues of the tendons. Strain stands out clearly as a bright, clean-cut, pulling quality in such perceptions as the lifting of a moderate weight upon the outstretched hand or as the bending sidewise at the hips. Its close association with movement has doubtless given strain its high importance in many performances of the organism. We find it playing its part in the perception of objects, of time, and of the bodily self; in memory and imagination, as well as in action, emotion and thinking. Its wide uses would seem to

suggest a high qualitative complexity in strain; but when we regard the tendinous quality by itself it evinces great constancy and uniformity whether it derives from the pull of the frowning muscles, the sag of the mouth, the clenching of the fists, the straightening of the back, or the rhythmical walking movements of the legs. The use of these bodily postures and changes in our psychological functions is highly varied; but no one has found a like qualitative variety when the bright pulling tendinous component has been analyzed out and separately observed. Only a local reference to the place of origin within the body would seem to distinguish one strain from another.

The term *kinaesthesis* has been widely used to denote a fusion of those qualities (chiefly strain and articular and muscular pressures) which are produced when a movement-apparatus (*e.g.*, the swinging arm or the clenched fist) is thrown into operation. This is a very common resource of the organism in the perception of body-movement, of work wrought upon heavy and resistant bodies, as well as in many of those perceptions of the material and the internal constitution of objects where our own muscular efforts are involved.

These somaesthetic resources of the organism appear suspiciously meager and inadequate for the functions which they serve to carry. Inadequate to the varied functional products, for the cutaneous and related senses supply, in large measure, our varied and abundant apprehensions of the superficial properties of material objects, of their size, shape, movement, roughness, smoothness, bluntness, softness, hardness, oiliness, slipperiness, wetness, stickiness, and so on. Many offices; few qualities! But inquiry into this apparent paradox makes it evident that many of these superficial qualities are carried by the integration of two or more of our qualities (*e.g.*, wetness by fusion of cold and pressure), while others originate in intensive, extensive and durative patterns of a single quality,

(*e.g.*, roughness and smoothness by patterns of pressures). The apparent inadequacy as regards our perceptions of bodily states and changes may be resolved in a somewhat similar fashion. We depend primarily upon qualities from the thoracic and abdominal viscera for our perceptions of the states of health, energized alertness, nausea, seediness, and the like; for perceptions of hunger, thirst, sexual analepsis and general exhaustion; for a very wide variety of moods; for the 'organic core' of the perceived self; and, finally, for the bodily reference in many of our emotive seizures. Again integration plays its part; hunger and thirst depend upon fusions of pressure, temperature, and pain. For the perceptions of state of health, alertness, and the like, we must add tendinous strain; and in the self-referring perceptions, the emotive 'stirs' and the 'deficient' states, we must play the changes upon our simple qualities combined in many specific fusions and patterns. As the chemist and the anatomist know, it is possible to produce an incredible variety by the varied combination of a few ingredients; and in precisely this fashion the organism bases its wide range of perceptive apprehensions upon the integration of a relatively small variety of receptorial functions. [47]

Do Memory and Imagination Involve Novel Qualities?

It is a striking fact that, when we imagine or recall, the brain itself compasses the task of producing the qualitative variety which is, in perception, initiated by the receptors. Thus we accomplish the feat of seeing the past with our eyes shut or elsewhere engaged, of hearing songs 'in the head' without the use of the voice or the ears, and so with some of the other senses. Noting these differences between the perception of the present and the other related modes, psychologists have commonly said that 'sensations' were chiefly involved in the former and 'images' chiefly in the latter. They have also de-

scribed intermediate instances where both kinds of 'elements' came together and supported each other. A thoroughgoing qualitative difference between the two kinds has, however, never been made out. As we shall regard the facts, the important thing is that the organism should be able to carry on the same type of operation by the use of diverse resources and means. We shall therefore be keen to discover, so far as we can, how the organism perceives, remembers, and imagines.

Here we shall be profoundly helped by observing *the principle of functional residues,* a principle based upon the fact that organic activity, whether psychological or physiological, so leaves its mark that operations are modified by their functional antecedents. In remembering and imagining we do find—as we have observed—qualitative patterns of the same type as in perception. Nevertheless, eye and ear, tongue and tactual receptor do not here play their rôles under stimulation. This bodily office has been filled by the central nervous system. What the actual character of this operation is we unfortunately do not know. But if we look to the brain for anything to match the several receptors or for any structures that suggest the storage of memories, we shall be grievously disappointed.

When the neurologist discovers the essential nature of the central processes which obtain during perception itself, he will doubtless have the key to the bodily support of remembering and imagining. In the meantime, we shall do well to observe again that it is not a case of substituting the brain for the sense organs—since the brain is engaged in perception just as essentially as it is in other forms of apprehension—but of carrying on the same type of function, in remembering and imagining, by a fractional part of the bodily means employed in perceiving. This sort of bodily economy we shall often meet in the short-cuts and elisions of behavior. A part comes to serve in place of the whole mechanism. We must also

consider that the entire movement apparatus, the glands, and the viscera are free to coöperate in apprehending the absent, the past, the future, and the fictional, as they also are in perceptive operations.

Apprehension and Feeling

Our examination of the qualitative moment in the functions leads us inevitably to the problem of feeling. Here we shall not follow the lead of those psychologists who find the root of feeling to lie in an affective element, such as pleasantness or excitement. In part, we shall leave feeling to be considered in connection with emotion. But this disposition does not wholly suffice. We must also remark that this important aspect of psychological function derives from an aspect of living that is both general and profound. Let us see what it is.

It is obvious that the study of the apprehensive functions does not directly touch the problem of feeling. It is the genius of those functions *to announce objects and events to the organism.* By way of them trees, landscapes, moving objects, living beings, the work of the steam-shovel, and the melody of the music are announced. Neither is apprehensive announcement limited to outside things, changes and occurrences. Bruised flesh, aching teeth, a tense abdomen, and stiff muscles are likewise announced. But in feeling (especially feeling in its simpler forms) the active organism announces (so to say, to itself) certain global and general turns in its living existence.

Some men have thought that surplus and deficit in the metabolic state of the body at large were announced in pleasantness and unpleasantness; *i.e.,* that a balance on the side of building up gave rise to pleasantness and the opposite balance to unpleasantness. Others have regarded the general state of the brain as similarly involved. Such theories are as difficult to prove as to disprove. Of late tactual receptors have

been invoked to engender feelings. What precisely the bodily resources are cannot now be said; but so far as the feelings enter into our functional performances the organism is, in a non-specific and non-local way, announcing certain broad turns in the course of living.

At the same time, this primary aspect of feeling is also modified in various directions for the accomplishment of other ends. One direction is *sympathetic:* we feel our way into the state and intent of other human beings, suffering and enjoying with them. We appreciate them rather than know them. A second direction is aesthetic or *empathic:* we inject pity, courage, or relentless rage into the tragic picture, the sculptured explorer, or the devastating hurricane. Thus from the announcement of our own state-at-large, feeling comes to serve us in a symbolic way with regard to the state and attitude of other men and of natural objects and forces. In another place we shall see that feeling naturally and inevitably supplies the coloring and the fire to our emotive predicaments. Since it is the primary office of feeling to refer to the bodily self and its states and tempers, it is natural that the apprehension of things as in my present, past, or future, should be facilitated by this 'global and general' announcement of the organic states and tempers. Language recognizes this implication of feeling in distinguishing the feelings of recognition, of familiarity, of actuality, and of the unreality of the scenes of imagination. It is also this general reference to the organism at large which leads one to speak of 'my' memory or imagination whereas the perception is impersonal and shared by others.

The Integration of Objects

The wide variety in receptorial device and excitation and the great qualitative multiplicity springing from these neural sources suggest a reasonableness in the vast range of our perceived objects and scenes. These resources justify, so to say,

the amazing number of different items apprehended among the furnishings of the earth.

But we may carry this reasonableness a step further. We may discover that the very energies of stimulus and the natural but complex ways in which these stimulating energies are combined bring to an attuned and responsive organism—of the same fiber and tissue as the active and impending world beyond its epidermal covering—the apprehension of the many things and processes of the known world. [48]

When we examine the properties or peculiarities of the physical and chemical agents which serve to excite the receptor organs, we discover certain characteristics which are common to all of them. These are *kind, intensity, extent,* and *temporal course; i.e.,* the stimulus is mechanical, photic, acoustic, thermal, etc., (kind); it is strong or weak (intensity); it is confined to a small group of rods and cones, extended over the whole retina, or limited to a single cutaneous hair (extent); and finally it endures a short or a long time, is steady or interrupted, periodic or irregular in sequence (temporal course). Now any one of these properties of the agent exciting the receptor may set the pattern or arrangement of the stimulus and so (by way of receptor and brain) help to govern the psychological function and to determine the object apprehended. Let us examine these four properties in order and discover their psychological significance.

Kind. Illustrations are to be found in the musical chord and in the odorous composite of chemical substance. Here variety in the stimulus leads to *fusion* in the result. Were each tone in the chord or each chemical ingredient to be delivered separately and severally at appropriate receptors, the effect upon the organism and upon its functions would be quite different from the combined, synchronous effect, where the receptor-functions may be said to be *incorporated* into a whole. We say 'fusion' because the constituent qualities are made

relatively obscure by being given-all-together. Each gives up something to all in the incorporation. The *c*, the *e*, and the *g* of the common chord retire, so to say, to produce *ceg*. A large part of music is built upon this fact of fusion or incorporation.

Within a single sense, minor variations of kind may materially affect the closeness or the looseness of the fusion. The most striking instances of this dependence are to be found within audition, where the closeness or the *degree* of tonal incorporation is primarily determined by vibrational ratios. The greatest infringement upon quality appears where the vibrational ratio-numbers are the smallest, the octave (1:2), the fifth (2:3), the fourth (3:4); and the least infringement (among the ordinary musical intervals) where the numbers are relatively large, *e.g.*, the major and minor sevenths (8:15, 9:16). That this infringement is not based upon nearness or remoteness in the tonal series is clearly shown by the fact that the octave and the sevenths (both large intervals) stand at opposite ends. [49]

Another instance of the dependence of fusion upon the interrelations of stimulus is the *vocal sound*. The wide resources of human speech largely derive from the fact that tonal and noise qualities coalesce into a great number of characteristic fusions; those represented by the simpler phonetic sounds and their combinations. The larynx and mouth, sounding together, give rise to a complex of periodic and irregular vibratory movements of the contained air which produce the tone-formant-noise fusions of speech. In describing the simple vocal sounds in an earlier place, we discovered that the formant is a dull, soft accompaniment to the fundamental, with its pitch retired and obscure. This fusion of formant with fundamental and other partials characterizes the vowel sounds, while the consonants generally add noise components and a characteristic temporal course.

Still another instance of dependence upon kind is furnished by *clang color*. The peculiar and characteristic sound of a given musical instrument is due to the fusion of tones of

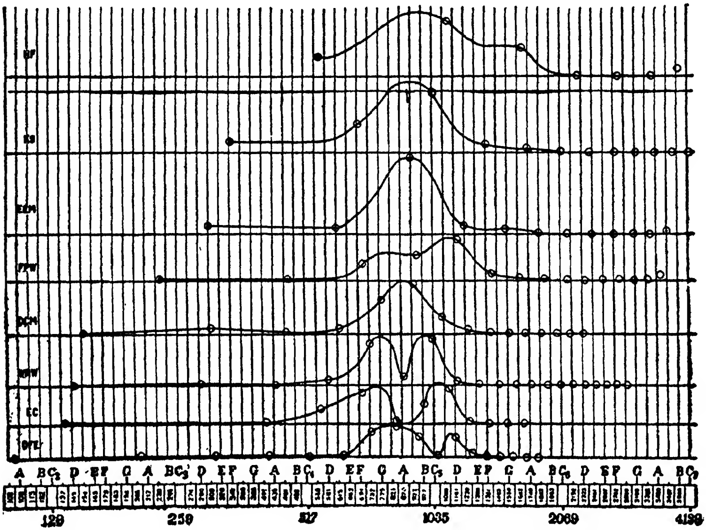


FIG. 37.—DISTRIBUTION OF PHYSICAL ENERGY FROM EIGHT DIFFERENT VOICES PRODUCING THE SAME VOWEL

The eight different voices were pronouncing the vowel *a* (as in *father*). The loop in the vicinity of 900 vibrations represents the physical side of the formant or 'characteristic' for this vowel. This general region is constant; although the eight sounds are intoned on fundamentals ranging from 106 vibrations (bass) to 522 vibrations (soprano). [From D. C. Miller, *The Science of Musical Sounds* (The Macmillan Company, New York, 1916)].

fixed pitch-relations, to which are added various noises incident to the scrape of the bow, the wheeze of the pipes, the thud of the drum sticks, and the like. Musical practice regards the note, with its characteristic clang color, as ultimate in

composition; but it is, as we now see, really a closely fused mass of individual members incorporated in a definite and definable way.

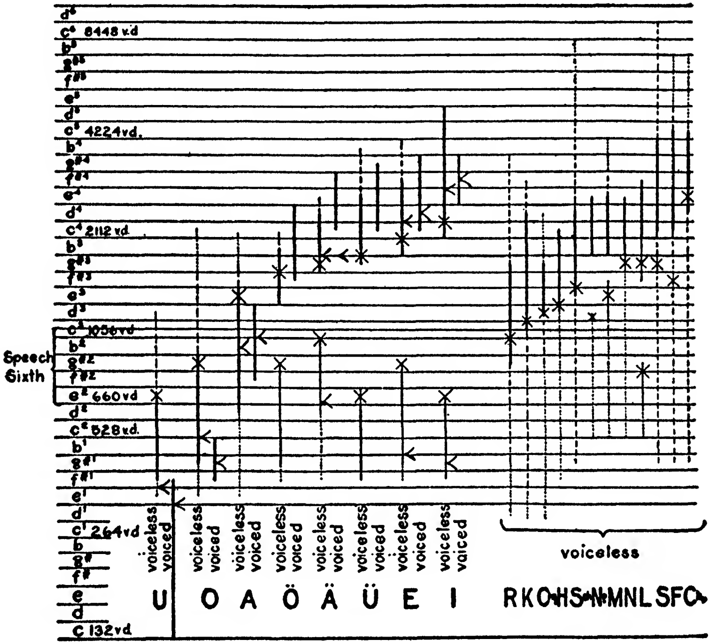


Fig. 38.—The Place of the Primary Formants (Heavy Vertical Lines), Secondary Formants (Light Lines), and Characteristic Partial Tones (Crosses) in Many Vowel and Consonantal Sounds

[From R. M. Ogden, *Hearing* (Harcourt, Brace and Company, New York, 1924)]

Intensity. The intensity of stimulus also plays a part in incorporation; but its part is rather to emphasize certain parts or members of the object than really to create a new sort

of connection. It makes certain members prominent and certain other members inconspicuous. Like variations in kind (such as we have just now described in tonal fusions), intensive variations also exert an influence upon incorporation. In the note, *e.g.*, one tonal quality, the fundamental, is, as a rule, relatively strong; the remaining sounds, the overtones, relatively weak. The strong component carries the note, defining its pitch-place in the musical scale and determining melodic structure. A similar effect of intensive differences appears in the arts of the florist and the perfumer. A pleasing olfactory complex may be provided in the bouquet or the synthetized perfume, where one or two components are strong and emphatic, while other, weak components serve only to give piquancy to the whole fusion.

Extent. The extent and the spatial distribution of stimulus offer the third kind of support to the unitary structure of objects through the mediation of receptors. Extent underlies, in fact, a special kind of arrangement. You have but to glance at a row of books upon the shelf or at a pattern in the wall paper to realize that here visual qualities (reds, grays, blues, browns, etc.) have been combined in a way that is quite unlike the incorporated tones and noises in the note, in the chord, and in the vocal sound. The colors of a picture do not, as we have seen, interpenetrate. They remain somehow 'outside' each other. And nevertheless they *go together*. One group of colors taken-all-together makes up a human figure, another the sky, and so on.

You will realize upon reflection that this kind of integration plays a part in our apprehension of the spatial attributes and the spatial relations of objects in the physical world. Suddenly glance at an inverted picture with which you are not wholly familiar and then at the same picture right side up. One object is 'the picture'; the other is a blotch of colors or grays, or else quite a different picture. So far as the visual

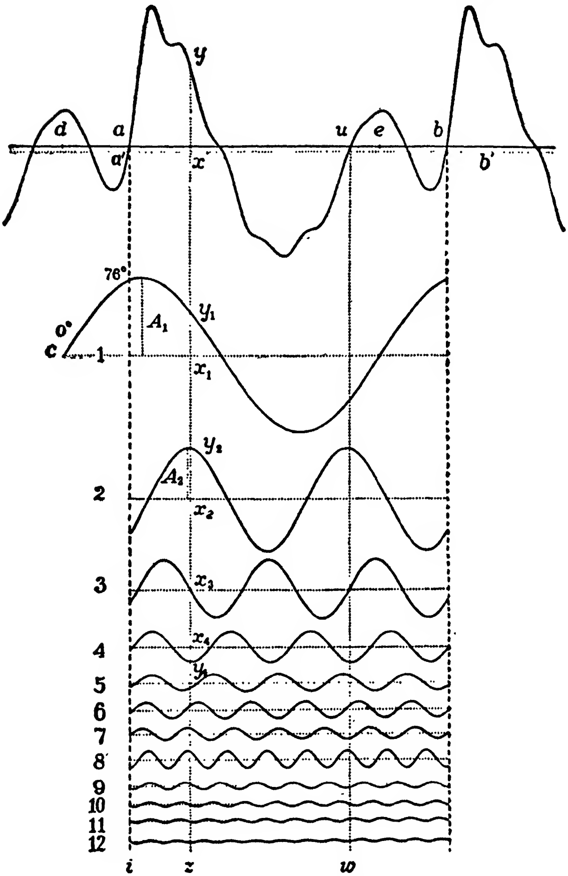


FIG. 39.—AN ORGAN PIPE CURVE AND ITS HARMONIC COMPONENTS

The upper curve represents the total displacement caused by the pipe. The lower curves show the total resolved into its twelve components representing the relative vibration rates, 1, 2, 3 . . . 12. Each component corresponds to a simple tone. The fusion here is very close and the dominant pitch is that of the fundamental. [From D. C. Miller, *The Science of Musical Sounds* (The Macmillan Company, New York, 1916)].

FIG. 40.—CHAOTIC EXPANSE

When inverted, picture appears

qualities are concerned, the two objects are the same, but as actually seen they are quite different. To be sure, some of the conditions of this difference lie within the central nervous system; but that fact will not disturb your present comparison of these two arrangements and orientations of a stimulus-pattern which lead to two unlike perceptions.

Temporal Course. The temporal factor in stimulus remains for our scrutiny. It is of very great importance. In the melodic phrase such a tonal sequence as e-c′-g-c is not a mere string of separate tones. It possesses unity, coherence. In a real sense it is one. The same may be said of the elements or beats of a rhythmical measure. Three even clicks given thus upon the metronome, click, click, click, and repeated several times, arouse an auditory perception whose formal or integrative aspect may be represented as follows:

CLICK,click,CLICK, CLICK,click,CLICK, etc.

The whole line is a structure. It contains within it successive members, rhythmic units or *feet,* each of which has characteristics distinguishing it from every other. Not only has each sound in the unit its own prominence or accent (strong, weak, moderate, in our instance); variations in prominence, from foot to foot (1, 2, 3, 4 . . .), make each foot, as the rhythm grows, a unique and individual member of the whole structure. To rearrange these members or to modify their character would precipitate a change in the entire rhythm. It has been found by experiment that, within limits, the longer the periodic recurrence of stimulus continues, the closer is the integration and the greater the individuality and character of the rhythmical object.

Over and above the mere repetition of neural excitation at the receptor, the stimulus makes other temporal contributions to the establishment of the rhythm. While repetition is usually sufficient, provided a fairly constant interval is maintained

between successive strokes of the metronome, a regular alternation of intensity or of vibration-rate within the stimulus series, such as

STRONG, weak, weak STRONG, weak, weak, etc.

or

Low, high, high Low, high, high, etc.,

serves to strengthen the organization and to take over functions in rhythmization which are otherwise left to the control of the nervous system. It is this sort of encouragement to rhythmization which is provided in dancing by the large drums in the orchestra.

There is still another contribution made by stimulus to the temporal incorporation of rhythm. Most, though not all, rhythms include a somaesthetic factor. The body contributes, in the contraction of muscle and the pull of tendon, qualities of alternating intensities which help to put the succeeding members into their places. It is in large measure this factor which is responsible for the knitting up and the individualization of the rhythm just indicated.

Our account of these temporal perceptions, illustrated by rhythm and by melody, would lack an essential part of the description did we not go on to explain that the individual members of the rhythm and the melody do not exist merely within the temporal place indicated by the stimulus. In the rhythmical unit,

SOUND—— sound—— *sound,*

we do not have one quality running its course and dying, only to be succeeded by another, and this in its turn by a third. The sounds exist together. And their togetherness is plainly related both to the fact that when the strokes or the notes come too slowly the integration is wanting and also

to the fact that the togetherness is increased as the rhythm goes on, the members becoming more and more closely integrated. In rhythm and in other like temporal perceptions, the object, which is at once one and many, wears a curious aspect. As *one,* the thing is together; as *many,* its members stand articulated in time. Instead of the qualitative interpenetration and the spatial standing-aloofness displayed respectively by the fusion and the 'extensive' type, we find here a *temporal* interpenetration and at the same time a temporal disjunction. It is a little like the clock-dial in the tower, which is present all the time while the hours and the minutes nevertheless appear only in their prescribed sequence and order.

It is clear that this curious feat of lasting-over without fusing-with its successors, which we have discovered among temporally incorporated members, takes us beyond our external conditions; though it is obviously based upon the temporal relations of the successive and discrete stimuli. In the temporal sequence we cannot appeal to a dying-out time in the receptorial functions, because these functions are clipped short with almost no tailing-off, which might serve neurally to connect the successive stimuli. We know also that the progress of excitation along the sensory nerve is close-clipt, too; so we must refer the melodic or rhythmic ligation to cerebral agencies. From other sources we are informed that processes in the brain (apparently electro-chemical processes) are integrated into single functional patterns, although the individual volleys from the conducting pathways follow each other discretely. This is as far as we can go at present—awaiting discoveries by the neuro-chemist—in ascertaining that curious before-and-after arrangement among the members of a melody or a rhythm where the whole melodic or rhythmic phrase is nevertheless altogether-present.

Division of Labor Among the Senses

The various forms of physical energy are indiscriminately showered upon the organism. Heat rays as well as light rays enter the eye. Light also falls upon exposed skin and a little of it even finds its way into the ear. The savors of cookery bathe the entire body, which is also accessible to sound. The first labor of the body in perceptive apprehension is, therefore, the sorting out of the indiscriminate stimuli. And here we see operative the *principle of preferential selection.* The receptors we have likened to highly selective receiving-sets tuned only to certain rates and forms of energy broadcast from many sources near and far. Light, which carries surface-patterns from objects, is effective with the retinal receptors. These receptors are well arranged, in a spread-out way, to affect the organism appropriately for the apprehension of surface, place, size, direction, and the like. The capabilities of the skin-receptors, while more limited in range and delicacy, are of the same sort. Were we eyeless and tactually anaesthetic, we should find it awkward to apprehend these spatial properties of objects and activities by way of the ear or of a patterned receptor-mosaic set—say—at the back of the mouth, where we should be compelled to gape and constantly turn around to make out the panoramic character of our surroundings. The perceptive functions of taste and smell refer chiefly to foods and to what may be called the 'diffuse chemical atmosphere.' Here place, size, and form count for little.

The auditory receptors, hidden in the bony depths of the head, directly reflect no spatial characters of size, form, and figure. Distance is apprehended by way of auditory intensity, and place (right and left)—as we have seen—may be apprehended by differences of phase and time in binaural hearing. The genius of this sense is the apprehension of the quality

of objects (chiefly musical and vocal objects) and the temporal course of things without the body. We may here anticipate the fact that the auditory receptors are especially adapted to serve the comprehensive functions displayed in conversation and in listening to public speech because they supply thousands of different qualitative and temporally ligated objects which are used symbolically in spoken language. The preservation and projection of sound-objects by phonograph and radio have greatly extended these aural functions and have also multiplied our musical perceptions. We may note again that the art of printing has enabled the eye to share in these operations in a way quite inconceivable in the absence of this astounding invention.

Division of Labor and Coöperation

While we call attention to the specific skills and preferential uses of the several senses, we must not lose sight of their coöperation. The body is constantly bombarded from head to foot, inside and out, with the various forms of energy. It is quite as important that the organism make an integrative use of this shower of energy, therefore, as that it proceed selectively by ear, eye, skin, and so on. It is the rule and not the exception that the various forms of stimulus and the various receptorial resources *cooperatively produce the object and the living scene.* We *see* the orchestra leader as we *hear* the instrumental sounds; we also *take postures, keep time, stiffen and relax,* and *suffer visceral changes.* All of these bodily operations, pooled and integrated, produce the music as we apprehend and enjoy it. The psychologist discovers similar integrative behavior at the dramatic play, in observing the landscape, in inspecting his neighbors, in scanning shop-windows, in dining with friends, in recalling a tennis-match, and in imagining the home where he is presently to be a guest. In fact, upon hundreds of occasions where the appre-

hensive functions are prominent do we draw upon dozens of bodily resources, which serve us integratively with a vast variety of intricate functional patterns, each with its own points of emphasis and each with its own course and termination.

The principle of selectiveness and of specialized labor among the senses is a perfectly valid principle; but it must be taken along with this second principle of receptorial pooling and coöperation if we are to have a just notion of the resources and the varieties of our apprehending activities. When we speak loosely of 'visual' perceptions, 'auditory' or 'tactual' perceptions, we must not forget that *the organism contributes at large and from multiple resources* in all these cases. The most that we can credit to the single sense is a point of emphasis or focus. While therefore we urge the importance of receptorial mimicry and imitation of the stimulating energies throughout and beyond the body, we must bear in mind the fundamental fact that, once started by these organic means, the development of the perceptive and other apprehending functions takes us far on the road toward multiple and varied contribution of the bodily means of support and of organic coöperation.

As we go on presently to discuss the other psychological functions we shall find the same organic coöperation there and also the same sort of integrative dependence of one functional mode upon another.

Central Neural Processes Actively Represent Natural Objects and Events

We have traced typical integrations of natural objects to qualities and patterns in stimulus and receptor. Now we go on to examine typical objects which are, at the moment, independent, either in whole or in part, of stimulus and of receptor, objects which are commonly known as 'images'

—images of memory, of imagination, and of the dream. As I now consider in recollection a certain painting by Carpaccio I note that it bears an obvious resemblance to the Arundel print which I may perceive if I lift my eyes to the walls of my study. So, too, the new melody which I make up or imagine as I sit here by the open window and the actually rendered melody which I shall pick out presently upon the keyboard in the adjoining room.

We no longer consider these objects as more 'mental' than objects perceived. They are—once more—in no sense 'in the mind.' Common instances are the remembered song, the street parade, and the swim of yesterday; the anticipated guest, picture-scenery of the novel's plot, and the voices and faces of fantasy. The impress of the environment is not simply momentary. It determines both the qualities and the organization of subsequent formations, and thus it extends its molding influence upon the character of apprehension at large.

At the same time, we must not lose sight of certain notable differences between the present, perceived objects and those bearing other tenses, for these differences are significant of the organism's varied activities. To speak in general terms, the memorial objects are, as a rule, those most like the corresponding perceptual form. If you can now command a melody or rhythm which you recently perceived, or recollect in visual terms the inverted picture, you will find that the present objects reproduce with a good deal of faithfulness (item for item) the original. Occasionally a remembered scene or event seems an almost exact duplicate, both as regards details and also as regards organization, of a corresponding perception. I hear again the clatter of the cymbals at the end of a florid orchestral passage. I see the red-blue discs with which I worked yesterday in the laboratory. I hear again the exciting rise and drop in the fire siren. Except for the con-

text, it is as if the physical agents were at this moment playing upon my visual and auditory senses.

Nevertheless, a careful scrutiny usually shows a less complete organization of objects and occurrences in such 'faithful' memories than casually appears; and if, after a longer interval, I were to examine the same memorial reference, I should probably find it still less definite and less faithful than now. In fact, one form of forgetfulness is due just to the breaking down of natural formations originally established under the pressure of stimulus. Try to reinstate, in imaginal terms, the exact arrangement of dishes and silver upon some table where you have dined but once. If your observation is carefully made and if you succeed in visualizing the table, you will find gaps in your recollection, gaps which you will automatically fill in from other sources to make your memory complete and logically correct. The knives and spoons which you do not 'see,' you may create for the occasion, placing them in conventional order at the side of the plate; while your table companions are filled in from name and by bits and shreds of true memorial reference.

Sometimes the object tends to change into conformity with an object of undated reference which the individual 'carries in stock.' This tendency is of importance for human development. The decline of the memory makes way for the schematic complexes of a more general reference. It also furnishes a functional preparation for imagining. Scrutiny of the scenes and faces which entertain you as you pursue the adventures of your hero or heroine in an interesting novel will convince you that your own imaginal embellishment of the story is largely drawn from sources which continued to serve as definite memories so long as they retained the original stamp of the perceived object. Thus a ruined fort which the writer once vividly apprehended as he read a thrilling adven-

ture of Cooper's *Leatherstocking* turned out to be an abandoned adobe house actually visited many years before. [50]

The fact that we reinstate by way of the central functions —uninstructed by receptor and stimulus—a whole series of happenings connected together in a *memorial train* makes it obvious that the brain is not limited here to such things as snatches of melody and glimpses of scenery. We may review a ride in the country and scarcely fail to include a single turn in the road or a vista of hill and valley. In time, to be sure, these functions decline. Scenes then blur, telescope, and drop out. As I recall yesterday's visit to the druggist, some details have already gone; but a good deal remains, and that appears in a characteristic manner. The formation is looser, and it presents notable differences in the clearness and the obscurity of the several parts. But in its integrative character the scene is of the same type as the perceptual scene of yesterday. Just as I looked around upon entering the store, heard the door close, noted the new magazines, and so forth, by virtue of incidents which were in part successive and in part simultaneous but *all together;* so now the same kind of temporal linkage and of concomitance may be displayed in the new formation. The same is true of those imaginational performances when we connectedly day-dream and deliver ourselves up to fantasy.

The Liberation of Cerebral Functions from the Influence of Stimulus

The development of our apprehensive functions has progressed by virtue of a declaration of independence issued by the central nervous system. The vertebrate brain gradually has evolved the round covering dome of the cerebral cortex, which is called the neopallium or new mantle. The neopallium makes this part of the brain less a runway between

receptor and muscle than a half-independent set of structures which originates and perpetuates functions on its own behalf. By comparing the behavior of a turtle or an alligator with that of a raccoon or a dog, you will be made aware of a decided difference. The turtle behaves much more at the behest of stimuli than the more independent creature does. While you may train or habituate the raccoon to specific responses, its general behavior is much freer and much less predictable than is the turtle's. And this freedom is still greater in man, even in infantile man. What some psychologists have called a fixed relation between the momentary 'stimulus' and the momentary 'response' (the SR relation) is only a limiting case not often met with in our behavior, except by artifice. *Central determination* of conduct, in some degree, is much commoner. This freedom used to be called the freedom of 'ideas' and of 'the will'; but we can observe this developmental tendency toward central initiation and determination without appealing to a free or a 'wilful' mind.

Even in perceiving, government and guidance of apprehension rest as truly and importantly upon cerebral and other bodily functions as upon the appeal of the environment by way of the receptors. The organism selects, holds, slights, and persistently weighs certain objects and situations to the neglect of others. And when we come to remembering and imagining, central dominance is still more effective. There integration of the apprehended scene and the continuity of the apprehended train of events are primarily determined and controlled by relatively free devices resident within the brain.

CHAPTER V

LEARNING

All bodily functions are events. They run their course in time. They have their antecedents, their distinctive characteristics, and their results. This is as true of the psychological as it is of the physiological functions. Perceiving and remembering go on in the same sense as circulation of the blood and gastric digestion go on. Until now we have confined our descriptions, as far as we could, to the single functional event, to a perceiving, or a remembering, or an imagining. But these events do not simply copy and repeat themselves, minute by minute, day by day, and year by year. The most extraordinary things happen to the functions as they are exercised, renewed and repeated. They are not only modified in various ways: they profoundly change the organism itself, its behavior, its capabilities, and its accomplishments.

We are accustomed to temporal changes in most inanimate things. The motor-car grows noisy, old furniture creaks, clothes become shabby, tapestries and flowers fade, and the very hills wear away. This is the well-nigh universal toll taken by time. But the changes of which we speak in the functioning organism are of quite a different sort. Instead of suffering loss and decay through time, the body both preserves itself under function and conserves its past activities, profiting by them as they go on and are repeated again and again. To be sure, the body has its period of growth and its period of involution or breakdown; but apart from these early and

late changes in the life-course, there is also a constant modification on the side of extension, functional range, and expertness. In the earlier part of human life, taking all the changes together, we speak of 'development,' a term which we might well employ for later decades too, except that we have reserved it for the years of immaturity, feeling a certain responsibility for helping the young organism through a period of partial or total dependence. We are therefore apt to think that increase of stature and of size runs along with the growth of function, both coming to the full at about the same time. These long-term changes, proceeding through years and decades, we leave for our studies of human growth and development. Here our interest centers in the changes which go on minute by minute and hour by hour as the organism exercises itself, dealing time after time with the same or with similar tasks or situations.

In our own day and within our own culture, these functional modifications are commonly collected under the name of 'learning' or of 'the learning process.' What is profitable for the psychologist to include under these terms we shall discuss a little later, only remarking here that our wide and fairly loose uses of 'learning' are readily explained by our concern for the schooling and private upbringing of the young, by the natural fascination of the processes of unfolding in small children, and by our preoccupation with the study and training of animals. Those animals in which we are most interested (pets, companions, and servants) we compel to go to school to us, our serious interference with their lives being instigated by an ardent desire to make them learn our ways and serve our ends. Of late, also, the psychological study of animals in the laboratories has centered in 'learning experiments,' undertaken to extend man's knowledge of the animal's activities and performances for their own sake. [51]

Our approach to the psychological problems of learning is

to be made through a preliminary description of what actually happens as a result of those functional exercises and repetitions which we have been discussing.

Habituation and Practice

We all know that those bodily processes of which the physiologist treats suffer amendments and extensions during life. Some of them appear and undergo change during the embryonic and foetal months, beginning promptly with fertilization; some first appear at or near birth, and others depend upon a more mature state or upon the late arrival of certain glandular products. Compare with these the psychological functions, which fall without exception well within post-natal life (at least in man). These appear at various times, variously interact, and suffer profound change during the life-course. We have now specifically to discuss what changes in course, temper, and outcome are here realized by functional employment itself and by its repetition.

The most obvious effects of functional exercise appear when a fairly complicated set of movements (as in sorting cards, pigeonholing mail, playing at tennis, and the like) is continued for some time either consecutively or with resting intervals. Presently the operation comes to be prompt, invariable, rapid, easy, and precise. These are, as we say, the natural effects of practice or of habituation. Other effects, which are assessed at a lower human value, are resistance to change and an incapacity to break the bonds and chains of 'habit.' It is obvious that the effects are many, diverse, and of unlike value to the practiced and habituated individual.

Not infrequently habit is regarded as a sort of faculty, a gift to the organism, which enables it to profit by the use of gradual acquisition. As commonly distinguished from instinct it is an individual acquisition instead of a racial endowment. Both terms are often but wrongly made to represent

powers; instinct a power hereditarily derived, habit a power or potentiality accumulated through a number of like experiences of the individual. The terms are made scarcely less misleading and illicit through their dependence upon the loose speculations of biology than are such words as 'will' and 'thought,' when these latter are used to denote the mere capacities and powers of an enduring soul. Both sets of terms call for careful and critical use.

While we freely and usefully distinguish practice from habituation, the psychological differences are more those of phase and duration than of kind. Where our attention is called to the early and rapid improvement incident to that functional stage when we are getting the knack of a performance—as in learning a game of skill or in learning to read aloud or to set the dining table—we note an awkward fumbling which needs, as we explain, a period of practice. On the other hand, it is only when the performance has reached a late stage of smooth and automatized running off, without elaborate preparation for, and recital of, the task in hand, that we regard ourselves as habituated or as having acquired a habit. But in both instances the psychological changes upon repetition and renewed occasion are of the same sort.

It is sometimes assumed in the discussion of habit that the main thing is the sheer channeling of mind or of body. We speak of the 'grooves' of habit; and we declare that 'practice makes perfect.' In his famous chapter on this subject James implies this sort of channeling effect where he approves Carpenter's declaration that the 'nervous system grows to the modes in which it has been exercised.' But of greater importance in habituation is *the series of modifications undergone in course.* Repetition offers many successive occasions for such changes. The young child learning to write under the guidance of an instructor has occasion daily to eliminate,

to alter, and to augment certain details of his performance. Useless and distracting movements of tongue, face, and legs are dropped; the pen is shifted to new positions and is dipped

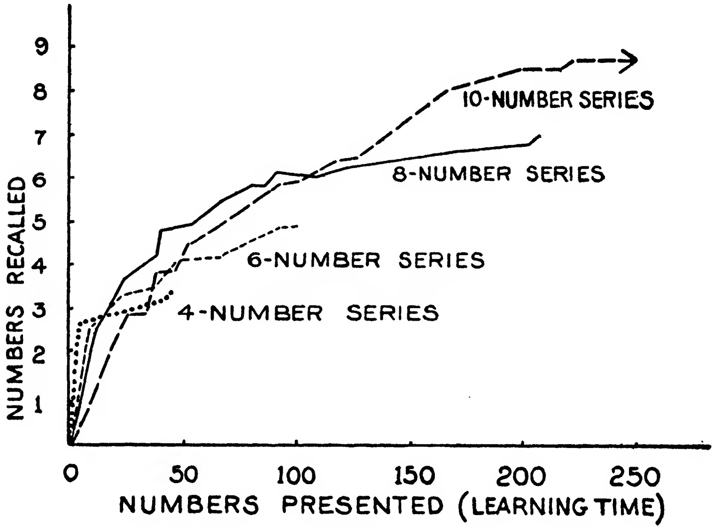


FIG. 41.—DEPENDENCE OF TIME OF LEARNING (FREE RECALL OF NUMBERS PREVIOUSLY READ) UPON THE AMOUNT OF MATERIAL

Three-place numbers were read in lists of 4, 6, 8 and 10 numbers. The progress of the acquisition (shown by the form of the curves) was about the same for the shorter and the longer lists. It took longer to learn the longer lists or series, but more individual numbers were learned in a given time when the lists were short. [After Robinson & Darrow (*Amer. J. Psychol.*, 35, 1924, 237)]

just before it dries; the hand becomes relaxed; the characteristic heights of the small and the large letters are noted; ways of connecting successive letters are acquired, and so on to a half-hundred or more modifications which tend toward

rapid, precise and legible execution. Research upon the stages of acquisition in telegraphy and typing has shown in detail many changes of this sort which mark its progress.

Five Results of Exercise and Renewal of Function

Now what is the character of these changes in course and what effect do they exert upon the functions themselves?

The first change is by way of *inclusion*. Inclusion means the incorporation into the function of some factor which was previously wanting. The child's excursion into a tempting mud-puddle may, on some occasion, be accompanied by a maternal "Don't; you will take cold." If the admonition is given effectively enough, the result of the 'don't' is likely to be written into the action. The action has been remodeled by the caution. The fact of remodeling is the same whether the descent to the mud is checked or carried through with the stiffened back of bravado. Again, the opening of the tube of dental paste will, on some hurried morning, lead to a drop and a fumble. One such incident may suffice to modify the manipulation of the tube. In all such cases the intruding element comes in, not by way of a simple addition but as a remolding and remodeling factor in the course of the action. Thousands of our simpler actions have been thus remodeled.

One common effect of this process is an extension of a performance to new settings and to new situations. The function is thus made more pliable and adaptable. It is not always easy to discover these changes in our own adult performances because most of our commoner actions have for years been seasoned by hundreds of inclusions which have come to meet the requirements of all common occasions. The history of early inclusions is already written into the actions. But where we observe the young child more naïvely attacking its new problems there we catch these inclusions just working their way in and we observe the resultant extensions actually

in course. This process accounts for much of the detail of socialization in the young child. Approval and disapproval, whether from parent, teacher, or companion, greatly modify all the psychological functions in course and bend them toward the accepted social forms. Just how and when these inclusions are to be offered to the child are grave problems in training and education.

The second form of modification is *substitution*. It is the fate of inclusion to introduce more striking and far-reaching changes in behavior than mere extensions to new cases and new situations. The included factor may come to occupy the primary place in the action and to crowd out or to modify a factor already incorporated. It will then serve to touch off the performance and to determine its direction and outcome. Here we pass from inclusion to substitution. This process of substitution has been made the central feature in the 'conditioned action' or—as it is less accurately called—the 'conditioned reflex.' The stock instance is the flow of salivary secretion upon the addition, and finally the substitution, of a ringing bell for the more primary device of placing certain foods within the mouth. After the process of 'conditioning,' which simply and favorably provides, for a sufficient number of times, the inclusion of the bell-sound along with the customary feeding, it turns out that the presence of food in the mouth may be entirely omitted and merely the included factor, the sound, retained. This included factor may then be made relatively stable by a sufficient number of repetitions. The possibility of this sort of substitution of that part of the performance which touches it off goes to confirm our statement that we have here a real re-integration of the function and not a simple tying together or bonding of separate activities.

When we consider that this kind of substitution may occur not once but scores of times and with scores of substi-

tutes for a given form of action, we realize how many perceivings or other instigating circumstances may lead to a single movement of putting forth the hand or a forward movement of the body or to any of a hundred bodily movements which enter into our daily actions. Replacement by new inclusions really supplies us with an embarrassment of riches. If we were impelled to act out all the performances that are implied by all the initiating circumstances which have in times past led to handling, advancing, retreating, or turning the head, the day would be filled with the most absurd and incoherent movements imaginable. There must be some check and there must be some principle of selection where inclusion and substitution have so greatly increased the incentives to bodily activity as well as to the other functions. These other modes of modification we shall look for as we proceed.

One of the important sequels of substituting that which was at first wanting, and then was present only as an included member, is the skill we acquire in acting from remote cues. When one is a novice in tennis, the return of the ball must be arranged by perceiving the exact course of the enemy's volley as it approaches one's racket; but with time more remote factors—the posture of the opponent, the swing of his racket, the straight or curving flight of his ball from its source—take the place of these primary things. So also with the swift movements of stenography, which finally run in connected series directly from the dictated speech. Factors so remote and so little integrated with the business in hand that they are quite lost on the unskilled come in time to be included and then primarily used to determine and to direct the expert action.

The exponents of the laboratory method of 'conditioning' sometimes give the impression that the Pavlovian doctrine first recognized the processes of inclusion and substitution.

It did not. The fact of inclusion and substitution has long been known. It is as common as the sight of the kitten or the chick running to the kitchen door upon seeing the door open or hearing the rattle of the spoon upon the plate. The ringing bell and the drooling dog are more striking and they bring in novel instruments not previously associated with the domestic animal. To the human observer the animal's concern with tuning forks, ringing bells, and electric currents seems to be remote; but to the animal itself these contrivings of man are obviously not remote, *provided only* they appear to the animal when a given physiological function (such as masticating) is actually in its undisturbed course. The value of the ringing bell and other apparatus lies, not in the revelation of any new basal fact about the organism assimilating new elements into old functions, but in bringing under controlled conditions these long-observed modes of functional modification. Under experimentation of the conditioning type many discoveries regarding the details of these modifications have been made. [52]

Since the term 'conditioning' has of late been used to cover practically every sort of change of behavior, attitude, and opinion, it is well to note that most of these novel uses of this popular word are illegitimate. The proper context of the term is physiological, not moral, pedagogical, social, or political. It is designed to cover quite specific and well-controlled inclusions of a bodily sort, where these inclusions lead to definite and describable sequels.

In the third place, functions change by *ligation*. Successive operations which are at first independent tend under repetition to merge into a train. This invokes one of the most important principles which underlie the gradual re-organization of a function. A large part of the developmental process in the individual's career rests upon the fact that repetition establishes new trains. The meager store of early infantile

functions, largely dependent upon visceral processes, the search for food, and the more or less constant dissipation of energy in random movements, is continually knitted under repetition, which binds the several members together into single sustained operations. If you will pick up twenty sheets of disordered paper, pile them neatly, and lay them carefully edge to edge along the table, you will discover that the movements are at first quite distinct but that, as you go through them time after time, they become briefer, less difficult, more precise, and ligated into one continuous activity. The same kind of temporal conjoining takes place when successive manipulations of a machine are carried through again and again in a definite order.

A fourth way in which repetition affords an occasion for remolding a function is the way of *elimination*. Where early performance is complex and awkward, many factors and parts gradually drop out as new occasions exercise the function. Thus in the child's early attempts at writing, in learning to dress and undress, to use table silver, and to drive the family car, the habituated actions come to be not only inclusive and ligated but also simplified through elimination or ellipsis. Not only do movements disappear as the successive phases of the performance are knitted together; the determination and the forecast of what is about to come suffer elimination. The action itself is thus simplified, foreshortened and telescoped. The child no longer bites its tongue as it writes; its bodily writhings are reduced in the management of its clothes; the free hand is less an adjunct to the spoon in securing food from the plate. In the same fashion do maneuverings of hand and foot largely disappear from the task of gear-shifting. So does the animal in the maze cease to explore blind alleys and the swimmer cease his awkward struggles to keep his head above water.

In the chapter on apprehending were described simple line-

patterns which were viewed again and again in indirect vision. After many perceivings the unsteady patterns became fixed and stable figures. The perceptive function was then said to have become *stabilized*. The same modification appears in remembering when one revives again and again an interesting scene from the past. The memorial scene becomes fixed and unchanging. This stable memory-product may not, to be sure, faithfully represent the actual original scene—in fact the memory may be quite distorted—, but it is fixed and stereotyped. In the Philippe experiments mentioned in the chapter just referred to, the features of a long-remembered mask continued to shift as time went on, but one detail (flowing Chinese mustaches) became fixed and invariable. This stabilization, which is more rigid than dependable for its fidelity to historical fact, is also strikingly displayed by the reminiscent harangues of the garrulous or the very aged. Even imaginings may suffer this same stabilization, as we all note who observe the favorite imagery reappearing in the writings of a critically studied poet.

A very important outcome of this process of stabilization is that the function comes to run itself through quite automatically. It may then be trusted to take an almost invariable way without guidance or oversight, as when the skilled worker tends the machine or the cook mechanically turns the eggs that attain a certain crisp smell and make a certain sizzling noise. This stable course would be economical even if the organism had no other occupation; but commonly it has others. The building of the rug-pattern as it grows upon the loom engages the weaver, who quite trusts his hands and his feet to look after the details of the shuttle and the threads. For such serious and laborious occupations as literary and artistic construction it is of the greatest importance that the mechanics of holding the pen, fashioning the letters, using the mallet and the chisel, and mixing and laying on the colors, should

be entrusted to actional functions which have long been stabilized and fixed.

The same five principles of modification under exercise apply to the functions which still lie before us in later chapters. They are of course notable in action, of which we first think when habit is mentioned; but they will presently appear also in emotion, in inspecting and comprehending, and even in serious thinking. The effects of repetition vary somewhat from function to function, but the types of modification—inclusion, substitution, ligation, elimination, and stabilization—remain the same. This would seem to suggest that, whatever bodily resources we use in our psychological performances, these resources are all subject to the same changes as a given function or combination of functions goes on and is repeated.

We may, then, be persuaded that the changes under exercise and repetition which we commonly regard as habituation flow less from a mere hammering in, as occasions increase, than from modal changes which may be factored into these five moments. We are not to understand, however, that these changes occur separately and externally to each other or that, as a rule, they come suddenly. They are rather moments in the functional remodeling which gradually occur as time goes on. We might bring them all together under the inclusive term *functional consolidation,* which suggests that during repetition the performance tends to be knitted up into a more compact, more appropriate, more economical, and more efficacious operation.

There is another peculiarity of the temporal course of function about which much has recently been said and written. It is the influence of the functional course itself upon subsequent behavior. The internal course and the issue of the performance leave their effect upon the organism. It has been shown that the rat, the dog, and the infant are left differently tuned where a well-consolidated set of activities leads to food

and where it leads to a sharp electric shock. A repetition of the activity is likely to take two different courses after the two diverse outcomes have appeared over and over again. At first it seemed mysterious that the outcome of a performance should be able to work backward and so influence the early stages of the next following repetition, as when food eaten after the event inclines the animal to take the food-ward course on the next occasion. But that is because we have a strong conviction that time and all that goes on therein move always and only in the one direction, that is to say toward the future. To correct this view you may remember that when we were discussing melody and other temporally arranged perceptions we observed that the earlier and later notes or rhythmic beats were present-all-together, while, at the same time, they had their several 'coefficients of place' in the total structure of melody or rhythm. Instead of being a series of discrete 'nows' succeeding one another in an unrelated way, the function is *one* in spite of the fact that it runs on and changes in time. The earlier parts of an operation stand so integrated with the later parts that when the organism subsequently comes to a renewal or repetition this influence appears in the new performance.

Were we to make an artificial separation of a functional performance (as the behaviorists do) into a part which is called the stimulus and a later part which is called the response, we might then find it difficult to explain why the response, coming after the stimulus and different in kind from it, should exert an influence upon it. The causal order 'stimulus-to-response' seems to stand squarely against a counter influence from effect to cause; but a recognition of the integral character of the total function helps to remove the difficulty. We have there something like a closely-linked chain where a force exerted at any single place is communicated to the entire structure.

The psychology of *Gestalt* gives a truer account than behaviorism of the effects of a performance being observable (in the form of learning) in subsequent performances, for it regards the function not as a separable stimulus and response, linked externally together, but as being integral and as running on in a certain direction until it comes to its proper end. The functions are *determined* occurrences and they are *closed* in the sense of running to a determined final term. When we once conceive of our psychological operations thus as single events, including initial, middle and final terms or phases, and when we add the five means of modification which appear as functions proceed and are repeated under variable conditions, we shall have the foundations for understanding the means and the products of learning. The explanation for the facts of learning we shall have to discover—as far as they are available—just where we discover the means underlying the functions themselves, that is to say in the active and living body.

With respect to the way in which the total function serves to modify the same (or a similar) function which follows it, we must observe that the exercise of any function so changes the organism that the next approach to the same situation finds a changed organism and leads on to a modified operation. We are apt to think that because the selfsame stimuli play incessantly upon the selfsame receptor organs, these stimuli have only to 'stamp themselves in' by repetition, a blind process of 'trial and error' directing the inefficient organism to the 'right' responses and so to 'learning.' It is the running of the function itself, as well as the product which issues from it, which appears on the second, tenth, or fiftieth occasion; and it is this functional plasticity, controlled by the products which it has previously made, which determines the various kinds of modification which we have seen to lie at the basis of learning.

Thus the melody which we gradually contrive as we listen

to a score played over and over is a differently colored and integrated melody each time we apprehend it. At first it wanders and falls apart, takes an uncertain course, and makes strange confusions with other and more familiar melodies. Presently its first three notes will suffice to identify it, and then it comes to be that particular melody, straining on to that particular rise, fall, and ending in whatever context it appears. Thus the whole history of our repetitions of the melody is somehow written into our practiced apprehensions of it. Not written in the sense of occasions remembered but as many functional changes. The same is true of our exercise of remembering, save that here we are usually intent upon recovering a certain face, scene, or occurrence, and so overlook the shifts in function—the eliminations, inclusions, and the others—while we hold to the past and dated object or event. And when we are no longer interested in the pastness of these things, we use them simply as material 'learned by heart.'

In many of our actions the kaleidoscopic changes under repetition and on the way to skilled performance are more apparent. The awkward male fumbles with the thread and the button; but if he persists in mastering a new skill, he will acquire the perception of the button held just so, the thread tied and slipped through the cloth at just the right angle, the holes in the button arranged thus and awaiting the unseen needle, which threatens to prod the finger, the whole performance ending finally with a firmly seated button and a sigh of relief. At the beginning, with tools in hand, the task arouses the action-determination, and a searching quest for completion carries it on. Once carried through, the action begins to change. Presently the new *inclusion* and *substitution* of a mere exclamation 'button off!' suffice to release the determination, the perceived situation is *stabilized,* the successive movements of hand and needle are more closely *ligated,* the pin pricks and profanity are *eliminated,* and finally the entire

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sequence of movements is *stabilized*. The task set the now self-sufficient male remains, to be sure, formally the same task; but the course and conclusion of the action are constantly modified; and always as the function changes it makes way for future and succeeding modifications. This is the way of learning.

Government and the Modification of Function

We have seen that functions in course and under repetitive renewal suffer modification in at least five different but related ways. We have also stressed the integrity of the total function and of the influence which all the stages of performance (especially the final stage) exert upon its future course. But the story of functional modification in time is not yet complete. In our first chapter it was explained that, wanting government and guidance, our psychological activities would be haphazard and chaotic; as they are, in fact, haphazard and chaotic in certain misgoverned states of the insane and the nervously instable. Since we cannot accept a foreordained government by instinct, reason or will, we must expect to find a means of government which grows and develops by perfectly natural and observable means, and furthermore a government which is as intimately related to learning as are inclusion, ligation, and the other moments which we have just now distinguished and illustrated. Let us see how government comes into our present examination of those forms of learning which depend upon the continuance and renewal of the psychological functions.

When you have turned back to the first discussion of government you will be prepared to "look to the living body with its actual history and in its actual context" to discover how many and what are the sources and agencies of government, control, and guidance (page 23). There you find that the general sources of government are three, extra-organic

sources, organic sources, and historical sources. We touch upon these sources in order.

Outside government. Under the first head we must observe the ways in which a function, say perceiving, is controlled by all those outside events which deliver energy to the receptors. Every morning we may perceive, through these agencies, the flooding of the world by light and at the opposite end of the day a complementary enshrouding of things in the evening's twilight. Here a certain type of perception of the world in change is repetitively arranged by nature for the organism. This is one sample of a large group of occasions for encouraging the return of a function which becomes habituated under the five modes which we have examined. There are also innumerable occasions in the individual life in which scenes and events are brought with variations to the organism over and over again. We should not go so far as the behaviorist goes in alleging that 'stimulus' is the only governor, determining every activity and every response of the organism; but all may accept the more limited governorship from this extra-organic source.

Here we must distinguish two ways in which nature governs. The first is by an orderly and systematized set of stimuli. Thus energy is delivered to the organism, not in a haphazard way but in patterns and trains of light, integrated in the orderly forms of vocal and musical sound, chemical combinations appealing to nose and tongue, and so forth. Nature thus supplies the organism with as suitable a means of guidance and control on the psychological side as Henderson has found it to supply on the chemical and physical sides in his ingenious work upon *The Fitness of the Environment.*

The second mode of 'natural' government rests upon the fact that animals and men are controlled not alone by raw energies but very much more by the objects, occurrences,

and laws of nature which are the product of their own psychological functioning. When the ground squirrel adjusts its wandering behavior by reference to its burrow, when the bee returns laden to the hive, and when you or I bring back from the links a flattering score at golf, all of these performances presuppose government by means of that which we have ourselves, as psychologizing organisms, made by way of apprehension, memory, action, and other like means. In this respect (and apart from the mere action of stimuli and receptors) nature governs and directs us and the other creatures only in so far as, and in the sense that, we have used the issues of our psychological resources to fabricate the world of things and occurrences. To be sure, the fact that we continue to live in this maelstrom of cosmic activities seems to justify our suspicion that we manage to get at and to understand the actualities of the world at least accurately enough to survive in it. But nevertheless we must not overlook the fact that nature teaches and schools us only to the extent that we are able to learn. [53]

Along with nature, taken in the sense of impressed energies and of observed and understood objects, we must recognize also human sources. Actions and emotions, even more than the forms of apprehension, are arranged for us by human beings. We act, fall into predicaments, comprehend language and gesture, and otherwise carry on largely under the influence and incitement of family, fraternity, acquaintance, teacher, and community. And to these more active forms of human influence and guidance, we add all the varieties of unspoken direction from opinion, custom, folkway, command, fashion and morals. Since this influence is constantly upon us, functional occasions are constantly renewed and repeated, offering an opportunity for all the habituational forms of modification which you now know.

Inside government. As for the organic sources of govern-

ment, the structure and the functional readiness and inclination of the organism always coöperate with external factors to initiate, direct, and complete a perceiving, an action, or an emotion, and to redirect the function when repeated. To perceive this or that and also to prepare the way for inclusions, substitutions, ligations, and the other changes from repetition to repetition, presuppose just as much a properly tuned and guided organism as an external occasion and a social guidance. Self-guidance, taken in this sense, is a mark of relative freedom from external circumstance. Learning in man is specially marked by the stronger influence exerted by the organism upon its own functions than the like processes in the young child and in the non-human animals.

All the way through the apprehending functions, we have noted the wide range of bodily factors (especially neural, muscular, and glandular) which are engaged in this form of self-government. One of these factors, the dominant neural trend, which carries the organism through a repeated function, relegating all other matters to a secondary place, has furnished to the neurologist one of the most difficult problems assigned to him in explaining the bodily support and government of the psychological functions. The neurologist's theories have assumed neural traces, molecular rearrangements, differences in electrical potential, facility of neural conduction, and many other hypothetical states and processes. Unfortunately no one of these theories is adequate, and the psychologist still awaits more intimate knowledge of the bodily processes which underlie the observed changes under habituation.

Government from the past. The third source of government lies in the history of the organism regarded first as a biological continuity and secondly as a biography. Here guidance of function presupposes heritage—racial heritage, heritage from the individual history, and heritage of the particular biographical

past which the individual organism carries with it. To meet an occasion and to address oneself to it in the sense of learning require this complex historical reference in addition to the natural occasion and the momentary organic state. And again we must insist that besides the exercise of government in learning, government is itself learned day by day and year by year. It is obvious enough that the body itself acquires wisdom in the guidance and conduct of its affairs. Comparing the infant, the youth, and the adult, it is quite plain that both the occasion and the direction of perceiving, remembering, acting, and so on, are more and more clearly selected and more and more aptly made use of as time goes on. But also is government learnt where government rests in human ways and human traditions. Norms and rules of conduct have themselves to be acquired, as well as the proper times for their application. The social side of governmental control—that is to say—is also a matter of gradual acquisition through the life-span of the organism. To learn self-control and governmental direction of function is quite as important an aspect of learning as is individual acquisition through a specific consolidation of the activity itself. This phase of learning we shall find to be of the very greatest psychological moment when we come to the examination of human growth and development.

Task and Instruction in Learning

In the experiments of the laboratory, questions of initiation, control, and guidance have most often appeared in the form of instruction—formal, occasional, and self-instruction (see pages 29-30 above). Here the experimenter takes a hand in government himself. He tries to set and to control at least those means of initiation and guidance which appear at the moment of experimentation. This he does in order that he may refer the observed modification of function in learning to the actual conditions which he has made. To this end he relates in simple

and appropriate words what is to be done (formal instruction); he controls his objects, lights, and outside sounds and he avoids distracting objects (occasional instruction); and he trains his observer to report whatever prompting to the task he makes by way of self-reference. Here is an instance of everyday guidance through instruction taken from a homely incident of yesterday. In my pocket key-pack are two similar keys usually distinguished by their positions in the pack. One unlocks the motor-car, the other opens the letter cabinet in the office. Standing near the cabinet and engaged in conversation, I handed to another the key for the car. The request for the key served as formal instruction. The sight of the cabinet served as occasional instruction. It led me to give the wrong (cabinet) key. The whole action ended in a dull feeling of unsatisfactoriness. Presently the action recurred in imaginational rehearsal. As the occasion was gone over, but without examining the key-pack, I realized my error. Self-instruction came in the comment "You usually know the keys: you must apologize for the mistake."

Now these instructional factors are of the greatest moment in learning under repetition, and, as we have seen, they can be strictly administered and controlled in the several varieties of the learning experiment. You will now be prepared to hear that the nature and extent of the learning, *i.e.*, the modified performance and its sequels, rest much more significantly upon these means of defining and continuing the task of rehearsal or recital, as the functions are renewed, than upon mere repetition of the perceiving, remembering, or acting. As we proceed to examine the functional changes in process, we shall see how the task, which is commonly supplied in the three forms of instruction, serves to carry through the modifications of learning. Although the modifications here take the same general course in man and in many other animals, the extent and variety of the instructions vary as widely as the

functional aptitudes which we find in cat, raccoon, bee, earthworm, monkey, great ape, child, and human adult. In general we may say, however, that all non-human animals, having a very meager self-object, draw into use very few instructions of the 'self' kind, and, wanting language, formal instruction is largely restricted to the commands of the human trainer. In the animal experiments, therefore, the emphasis is placed upon the occasion (the experimental setting) and the tuning of the subject by way of hunger, thirst, sexual stir, and the like.

The important factor that is commonly left out of many of these experiments is the fact that 'the occasion' is not, as a rule, the human scene and neither is it simply a congeries of stimuli. It is the occasion *as the animal itself makes it.* Without it the experimenter may very well read off in quantitative form the improvement of the animal day by day and so express the *effects* of learning the task which he (not the animal) has set; but he can never thus determine the actual *processes and nature* of the functional changes undergone by the animal itself. This is the chief limitation of the usual behavioristic form of the learning of animals, and the limitation is now frequently carried over into the corresponding forms of human learning.

The psychology of learning has invaded—as we have seen—two large fields; the field of action (from which our last instance came) and the field of verbal acquisition, the 'committing to memory' of prose, poetry, words, numbers, and nonsense syllables. The practical importance of skilled performance and the common use of words in school-tasks are chiefly responsible for the intensive and almost exclusive cultivation of these two fields. Both have led to much experimentation with human subjects, and the former probably includes two-thirds of all current work done by the psychologist on other animals. We shall then meet the topic again when we

come to deal with child development and with animal psychology. Here we must stop for a few experimental instances with the human adult.

Although we commonly include under *skill* all sorts of

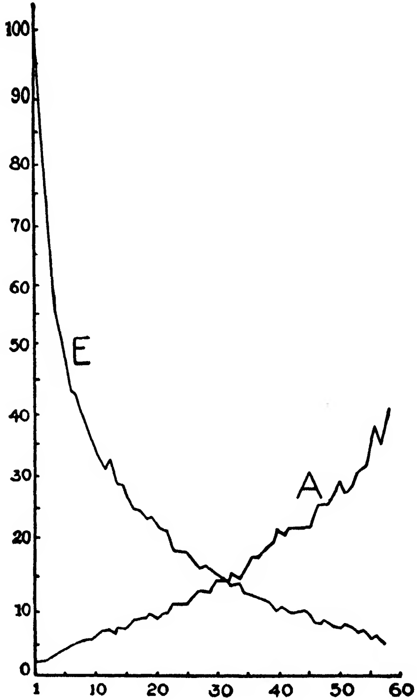

FIG. 42.—ACQUISITION OF SKILL IN BALL-THROWING

[From Peterson (*J. Exper. Psychol.*, 2, 1917, 201)]

fixed and steady performances which appear in bodily activity, skill is more like dexterity. A good instance of skill appears in experiments upon keeping in the air two balls

thrown in succession from a single hand. The accompanying figure shows (the E-curve) the number of attempts made each day in order to catch a ball 200 times. The other side of the figure shows (the A-curve) the average number of successful catches made each day between neighboring misses or miscatches. This represents attainment from day to day. There were twenty-five performers, twelve of these practicing every day and the other thirteen on alternate days only. On each day of practice the subject continued until he had caught a ball 200 times.

Although the mere curves cover more than they reveal of the actual factors operative in the continuance of an action, they do make it apparent that the organism is very differently engaged day by day and that the outcome of the function is steadily directed in a definite way. The reader must not conclude that these are 'typical' or general learning curves. They simply represent progress in a performance (measured in terms of an arbitrary outcome) attained with these particular subjects, under particular instructions, and with the particular conditions of the experiment. In this sort of experimental setting, more careful control and record of the character of the task under the various forms of instruction would throw considerable light upon the actual progress of learning from day to day. Such a record frequently reveals, besides the effect of instructions upon performance, the use of reports made by the observer to mark the course—with failure or success—of the successive stages. [54]

The second kind of actional learning is exemplified by the stylus maze. The figure illustrates such a maze used in the writer's laboratory. It is a heavy block of metal into which deep grooves have been channeled. A blunt-pointed stylus or pencil is introduced at the lower side of the maze and the observer, who has not seen the maze and who is blindfolded, advances the point of the stylus until it emerges finally in the

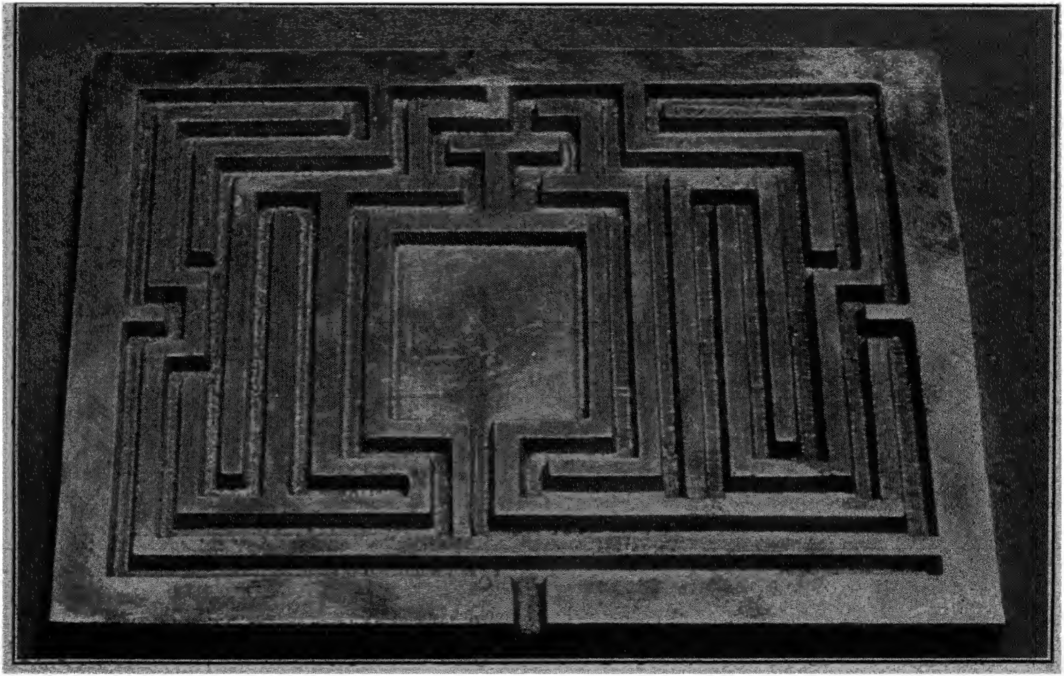

FIG. 43.—THE STYLUS MAZE

large central area. This area corresponds to the food-box in the animal maze. Before he starts, the observer is instructed (formal instruction) to advance the stylus continuously and promptly until he reaches the open area. As you will see, there are only two continuous paths to this central area, but there are many possibilities of going into blind passages from which the point must retreat. Upon completion, the process is repeated again and again until the 'correct' path is taken without diverging at any point, *i.e.*, without 'errors.' Here is a characteristic table of trials and times.

Trial		*Time*
1	many errors	24 min. 30 sec.
2	many errors	5 " 30 "
3	two errors	7 " 25 "
4	two errors	6 " 10 "
5	one error	4 " 5 "
6	three errors	5 " 4 "
7	two errors	1 " 0 "
8	one error	55 "
9	two errors	1 " 10 "
10	one error	45 "
11	one error	40 "
12	no errors	30 "

The course of the modifications from trial to trial depends upon the method of the observer and upon the means used to follow the correct channel. Frequently an imaginational accompaniment in visual pattern runs along with the action. But often there is only a series of actional determinations, represented in kinaesthetic form. This pattern gradually becomes *stabilized* and is then used to guide the stylus in the correct path. Stabilization is also facilitated by the pathfinder's anticipation of the end of the action. This factor would not be present in the cat introduced to a maze for the first time and unable to accept a formal instruction for the task. At times

a wrong turn is remembered upon retracing and is then marked by the comment "No; I must not go that way" (*self-instruction*). At other times a wrong turn is persistently repeated and then becomes an *inclusion* of a misleading sort; but when it is omitted upon repetition it serves as an *occasional instruction.* Where the several paths are followed through in the early trials as separate units, they tend later to be combined under the formal instruction and thus determine a single flowing action (*ligation*). According to the verbal instruction, the subject first starts upon command; but in the subsequent trials the finish of the preceding trial itself initiates the next (*substitution*). As the errors drop out, the action becomes *stabilized,* and at the end the entire function is run through in a consolidated and unitary way. [55]

The second large experimental field of learning is the field of memorizing. Although this is the field which is usually referred to by the phrase 'learning by heart,' it does not denote real remembering or indeed the exercise of any particular function, and neither does it imply any new or specific operation. It has gained its wide popularity, not by any unique learning process or acquisitive function, but by virtue of its outcome. As everyone knows, the rehearsal of words, sentences, scenes, or occurrences gives the organism the ability to use this 'memorized' material in the absence of the original sources. This is one of the great means of freeing the individual from the actual panorama and flow of the world's events and of substituting its own resources for these outside things. No wonder men easily speak of 'storing the past' and of 'reproducing' it upon subsequent occasion; but—as we now know—there is no storage of past events in the brain, taken in the literal sense, and there is no reproduction in the form of ideas. It is our old case of making the psychological functions useful to the organism by continuance and repetition.

The outcome of the procedure is of value to the organism

itself, for learning of this sort greatly extends its private resources, and it is of significance to education because methods of training have to take learning of this sort into account; but the primary interest of the psychologist in the matter is the description of the changes involved in course, together with all the factors which enter into association and learning by heart.

The typical experiment in this field consists in preparing series of (say) twelve nonsense syllables, such as the following:

jat	vah
baf	nuv
vil	bij
mub	nol
kex	yuc
gup	wef
vok	quk
rec	sib
zun	cek
poz	kas
bux	luh
tih	hoj

Sometimes double syllables are used.

turoz	rolef
gadub	betab
mepen	ginoz
dizat	lurak
zopud	pekif
fagum	dulet

A series of syllables is so placed upon a revolving drum or other means of exposure that the syllables appear one by one in sequence. Each syllable comes into clear view, stops, then passes on and is replaced by another, until all twelve have

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dizat	lurak
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fagum	dulet

A series of syllables is so placed upon a revolving drum or other means of exposure that the syllables appear one by one in sequence. Each syllable comes into clear view, stops, then passes on and is replaced by another, until all twelve have

been seen and read. The series is either replaced and exposed again and again or else it is put away for a minute, an hour, a day, or some longer period, and the subject is then instructed to repeat or to write down as many of the syllables previously seen as he can and in their original order. This simple procedure and scores of variations of it have made it possible to discover not only the extent of free recital after a given period but also a large number of conditions and circumstances which make this recital better or worse, fuller or less adequate. [56]

When we regard the conditions which play upon the functions involved in reading the syllables over and over and in reciting them at a later time, we find that they naturally fall into three groups; conditions effective during the reading (frequently called the time of *impression*), conditions effective after the impression is completed (during the *interval*), and conditions effective upon the functions when the syllables are spoken or written down by the subject (conditions of *recital*).

Among the conditions which are effective during the reading are all those which come with repetition. After our examination of the many opportunities for modification offered by repetition, we should expect in memorizing no more than in the firm establishment of an habituated action that mere repetition would be the principal factor. But the presentation of the nonsense syllables over and over rather does give occasion for inclusion, substitution, ligation, elimination and stabilization, just as we found in action. At first it might seem as if, in stripping language of its verbal significance by employing nonsense syllables, we had left only bare blocks of print and had reduced the organism to the sheer necessity of cementing these bare blocks to each other by the force of repeated juxtapositions. But that supposition has not been borne out by experimentation, which has shown instead that consolidating

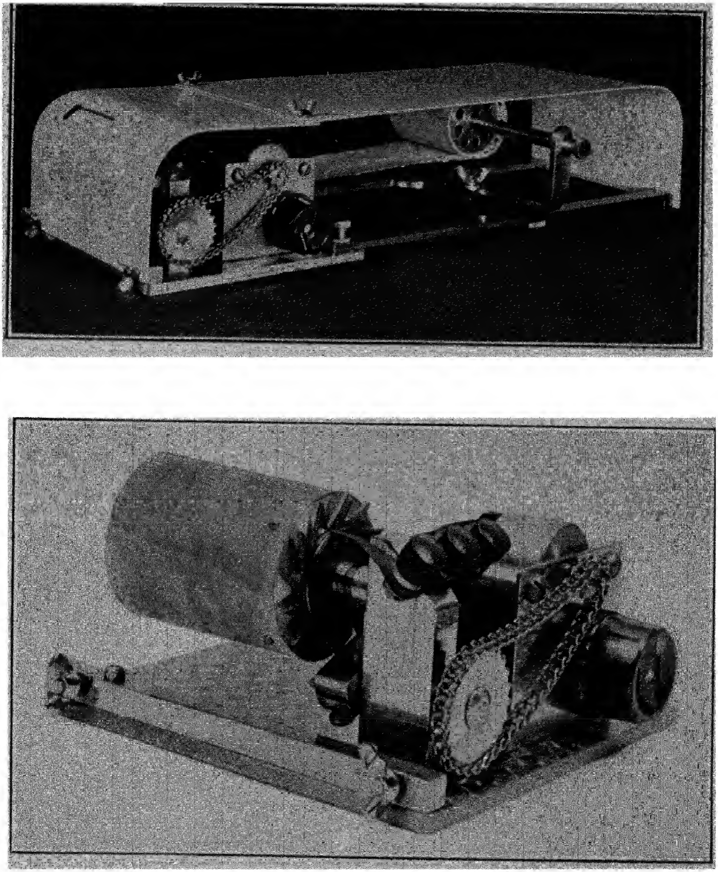


Fig. 44.—Cornell Exposure Apparatus

processes, in the form of the three kinds of instruction, by means of rhyming, rhythmizing, inventing relations among the successive syllables, bringing in ligating contexts of many sorts, stabilizing the entire function, and investing a whole series with a like intent to use at a later time, have all been effective and accessory means of building up an integral function which leaves its mark upon the organism and permits, among other effects, a subsequent free recital.

The nonsense (better, non-linguistic) combination of three letters very often suggests—in spite of every contrary precaution—a verbal form (for *nick* nik, for *some* zom, for *coke* koq, for *life* lif, etc.) or else the sheer sound carries a specific reference (zuz carries a saw-noise, lul suggests a soft thing, etc.). We are all so saturated with the implication of word-like combinations that we have to do more than avoid the stock terms of the dictionary if we are to free ourselves from these references and implications. The implications may be reduced by a formal instruction to the observer, "Do not regard the syllables as words," and reduced still more by changing the place of the vowel (*e.g.*, nik changed to kni, zom to mzo). But many other opportunities to ligate remain. A rhythm is common. If the syllables are presented in pairs they are commonly read as a rhythmical unit with the accent usually placed on the second syllable (as zir-kak′ or maf-muf′). Where the whole series is given in succession, it is common to make up larger rhythmical units and gradually to stabilize them as one would stabilize a rhythm made by tapping with the fingers. Sing-song melodies are likewise employed by some subjects. These and many other devices for an assimilative reading are frequently used without any definite self-instruction, the subject simply falling into a mode of reading; but many times the subject reports that he prepared himself for the final task of recital by 'noting especially the first letter of each group,' 'looking for easy groups,' 'placing the syllables in

imagined locations,' 'trying to find a suitable idea to unite two successive syllables,' 'stirring up an emotion appropriate to the sounds,' and by dozens of other devices. Even where no internal or contextual means of conjunction and consolidation come to hand, the letter-combination is still a black-white object presented at a certain place which may be integrated in all sorts of ways with adjacent or succeeding objects. [57]

The general outcome of these painstaking experiments with this form of learning is that the organism is given a task which looks forward to a certain outcome, that the task is initiated and continued in its course by many instructions of all three forms, and that these instructions (from the experimenter, the occasion, and the subject himself) create and use all manner of devices and aids to the final consolidation of the material. During the course of the reading, changes in the functions employed are *inclusions* (*e.g.,* outside materials are brought in), *substitutions* (the rhythmized sound of the word is substituted for the visual perceiving of it), *ligation* (successive syllables at first separately apprehended come to be conjoined), *elimination* (a single letter may be made to stand for the entire syllable and the outside cues may be dropped out), and *stabilization* (the series once started may be run through with complete continuity and without reference to the exposed material).

Thus we seem to find that the essential changes under continuance and renewal of these memorizing performances produce the same kind of functional modifications as we found in the acquisition of skill and in pathfinding. These experiments fail, therefore, to support the theory of external 'bonds' or 'connections' which have been alleged to tie together in a mechanical way separate and distinguishable elements. The whole primary matter of learning thus becomes a functional

procedure together with changes which occur in the course of this procedure upon renewal and continuance. [58]

Although learning in the cases which we have cited involves repetition of a function, or of two or more functions, it is obvious that the running through of the performance is the essential condition of the subsequent effects observed. We should therefore expect to find that *a single performance* also led to like subsequent modifications in behavior, although we should not expect to find so great a range of changes or so profound an effect produced by a single exercise. When we say that the pupil has learned his lesson by one reading, we imply that he was able subsequently to use information or skill or some other residue of his work after a single application. It is quite possible that a very short series of nonsense syllables would be perfectly recited thirty seconds after a single perusal, just as we carry away from the visit to a strange place a more or less coherent account of things seen and heard. All of the essential ingredients of learning are here at hand, save only the multiple opportunities which repetition brings. Of course, all of the influences which we have found to play upon the memorizing procedure (task, instructions, character of the materials) may also appear in the single trial; only here their opportunities are naturally more limited and less efficacious than with the multiple repetitions. Moreover, the single perception or action is much more likely to lead (as we saw in the sections on remembering) to a real memorial reference to a dated past event.

In view of the wide variety of means used at various times and by various observers in learning under repetition, it is obviously difficult to draw general conclusions from the experiments, conclusions which relate at large to the method of learning, to the materials, to the number of repetitions, and to the elapsed time. In other fields, to be sure, many individual

events of wide variability have been successively pooled to show statistical constancies and tendencies of high reliability. Possibly also here. Let us examine two representative attempts at general solutions chosen from many in this field of learning.

Whole and part learning. When a poem or a prose oration is to be 'committed' for future recital, it is a common practice to take the material in parts, sentence by sentence or line by line, adding more and more as time goes on. But the same result may be attained by reading the piece straight through, and then again and again. This is called 'whole' learning. The same choice of procedures is given in the maze as used by man or by animals; either pathway by pathway or straight through, time after time. In our instance of the stylus maze, we assumed the 'whole' procedure.

The question has arisen as to the relative efficiency of the two methods. Miss Steffens proposed to answer the question by taking the two methods (using like materials) in parallel performances. She employed both poetry and nonsense syllables. When free and errorless recital was taken as the criterion, the 'whole' method came out ahead by 9%, with the poetry, in terms of time consumed in repetitions. A much smaller advantage with 'whole' learning was observed with the syllables. Several other experimenters have confirmed this result. But Winch, using short and rhymed poems with 38 children (average age about 11½ years) found an advantage of 26% accruing to 'part' learning. The advantage varied widely, however, from poem to poem. And Reed found only 26 out of 113 collegiate students excelling (in poetry) with the 'whole' method. Here we must qualify by observing that the extent of the part and the size of the whole played a very important rôle. Pechstein also found that he had to qualify with respect to variants of both methods when he compared either rats or human subjects in the pathfinding of the maze.

It has been pointed out that the independent ligation of each part, when it is completed by itself, leaves a secondary tying together of the several parts for a subsequent and final task; whereas in 'whole' learning the entire material is ligated at a single consecutive reading.

Since the results taken at large fall out diversely with various materials, variety of tasks, and unlike subjects, it appears altogether likely that *no general solution will be found.* What is more hopeful is an examination of the actual procedures carried through from trial to trial in order to find what really happens by way of functional modifications. An analysis merely in terms of stimulus and response is not adequate to the problem. [59]

Distribution of repetitions and rest-intervals. The plan here is to compare like groups of subjects some of whom repeat without rest while others interpolate (say) one, two, three, or five days between their working periods. Thus the exercise of function is either *massed* or *distributed.* Ebbinghaus reported that about 68 repetitions in immediate succession called for the same amount of re-learning as approximately 38 repetitions when the repetitions were distributed over three successive days. In repeating and extending these experiments, Jost argued that this superiority of distribution was not due to fatigue in the long-sustained task concentrated in one day. When we come to the animals, we shall see that a similar result has been obtained. There again a qualification has to be made, however, regarding the time (early or late) when the rest-periods are interpolated. It may be that certain specific factors, as Lashley has suggested, (*e.g.,* loss of interest, variable application, or persistence of the task) only accidentally connected with concentration and distribution are partly responsible for the observed results. But instead of accepting a general solution set in terms of mere 'concentration' and empty 'rest intervals,' a solution which has usually been supported

by vague and speculative causes, it would be far more profitable to discover just what happens under repetition, taking into account not only the materials used and the formal distribution in time but also the actual employment of the organism both during the task and during the intermissions. In this problem of distribution, as in the problem of wholes and parts, the present need is not for premature solutions, assumed to apply to all animals and all learning tasks, but for a more careful analysis of the processes of the 'learner' himself. [60]

It is obvious that our discussions of this chapter have not covered all forms and kinds of learning which are dealt with in the books and researches. In the first place, learning is variously conceived and defined. One man would have it cover all modifications through experience; another would limit it to certain progressive trends under constant stimulation; another makes it the acquisition of skill in the performance of a task; a fourth uncritically extends learning to cover man's power at large to change himself, and so on.

In the second place, the primary locus for the concept of learning lies in education and connotes the processes and effects of schooling at large. It is here that we find men speaking largely of 'the learning process' as fundamental to growth and development. Our own meager treatment of the subject from the psychological side has kept pretty close to a series of changes brought about under the exercise and the renewal of psychological functioning. It has had also to limit itself chiefly to the more primary and simple of these functions. When we come on to the more complicated forms of action, to emotion, inspection, comprehension, and thinking, we shall find that these forms of activity are also fundamentally affected by exercise and renewal and therefore involved in learning. [61]

CHAPTER VI

ACTING

The Psychological Aspects of Action

The business of living keeps the creature active. A constant interchange goes on between the organism and its surroundings. Observe your own behavior for a half-hour. Note the turning of the head to look or to listen, the manipulation of objects, shifting in the chair or on the feet, walking, speaking, exploring, the taking of food, dressing, greeting companions, and so on and on. In animals life does not, as a rule, go far without movement. The very processes of metabolism throughout the body usually require that the creature shall suitably maintain by movement his relations both to the gross physical agents, such as air, light, moisture, and a favorable temperature, and to particular and varied objects, to food, companions, and shelter; in short, to the whole changing panorama of existence.

Movement within the organism and among its various parts and members likewise plays an important part in the life of the animal. The trunk moves upon the legs, the neck upon the trunk, the fingers upon the hand; and within the interior the muscles move upon each other and the visceral organs shift with change of posture. Where the plant extends itself by growth and the accession of new parts, the animal manages itself and makes its adjustments to outside objects and forces by way of movement.

Now these movements of the organism interest the physiologist. They represent one great class of the bodily functions.

The physiologist may leave out the psychological activities and seek simply to ascertain how the movement apparatus—bones, muscles and tendons—is made, how it works, and how it is incited, controlled, and coördinated by the nervous system. The movements also interest the biologist, who sees in them devices for maintaining the organism and for moving it from one place into another. He is likely to regard them as an adaptive mechanism serving the organism. The study of motor behavior is a kind of active ecology seeking to describe the way in which the individual disposes himself in his changing surroundings. Again, the student of sociology observes the performances of men in order that he may understand their conduct and the ways in which they accommodate themselves to each other in social living.

Some psychologists regard these three treatments of organic movement, the physiological, the ecological, and the social, as exhaustive. But if we stop with them, we shall fail to see that movement enters, in a characteristic way, into one of the great types of function in which psychology alone is specifically concerned—into the executive type called action.

By *acting* we shall understand something more than bodily movement, something more than the putting forth of the hand to grasp or to repel, or of the movement of the legs in flight, and something more than an adaptive 'response' to stimulus. Acting is a psychological function which commonly begins with a task to be performed in a certain way and issuing with a certain play of muscle and roll of joint surface which effect a movement, local or general, and result in the pushing of a button, the turning of the head, the transfer of the body from place to place, or the inscription of a signature. While the movement and its results do come into the action they come in only at the last stages, completing and discharging the actional function, which begins the instant any hint of a future executing performance comes into existence.

To act, in the sense of a specific psychological function, is (1) to set and to face a task or problem, a task which looks forward to an executive form of resolution, (2) to carry through a determination, and (3) to lead forward to a resolution by way of movement. The movement involves contraction of muscle and the resulting displacement of bodily masses and of other objects. In other words, the organism invents a problem which it proceeds to solve in an executive manner. Always in acting something is to be done. The ink bottle is to be opened; the call from the telephone is to be answered; the friendly hand is to be grasped; the task of closing the house for the night is to be done; the direction upon the trail is to be determined and followed; the motor-car is to be guided through the street, or the radio is to be set for a promising station. We are constantly formulating and working out action-problems. In the course of the action the problem is on its way, the performance is in process of execution. The action progresses. And finally appears the solution. The thing is done. Some bodily movement is carried through and the action is complete. The function is thereby terminated. The typical and complete actional function may therefore be represented as progressing in the following way:

(1)		(2)		(3)
Formulation of task	>	Progress of the determination	>	Resolution through movement

Presently we shall find many variants of this typical action; but the generalized formulation will serve as a useful guide throughout our description.

In the laboratory, acting (in the psychologist's sense) has been diligently studied by many clever methods of experimentation. The best known of these experiments is the *reaction experiment*. Since experimentation always tries to bring

the event to be studied into clear-cut and observable form, and in a form that can be reproduced and repeated with all manner of suitable variations, it is important that the beginning, the course, and the ending of the action should be arranged

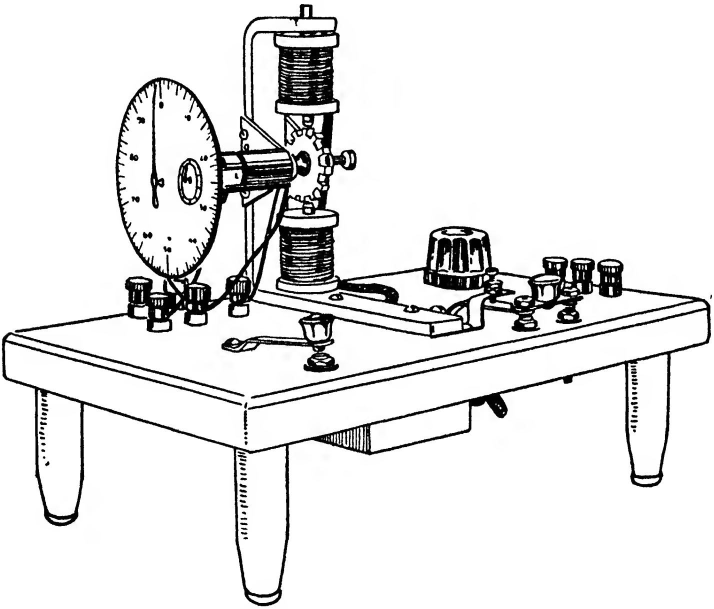


FIG. 45.—CORNELL ELECTRIC CHRONOSCOPE

By the depression of a key on the chronoscope, the experimenter simultaneously produces the sound and starts the clock. By the depression of a second key, the observer stops the clock and thus completes his action. The time-unit of the clock is $\frac{1}{1000}$-second (1 sigma).

and controlled. These things this experiment accomplishes in the following way.

Two provisions are made for the inception of the action. First, an object about which something is to be done is sud-

denly presented (by way of eye, ear, or skin) to the observer. Secondly, the observer is prepared by an appropriate formal instruction. Suppose that the object is to be presented to the ear. Then the instruction runs: "Just after a warning 'ready,' you will hear a dull brief sound like this (giving an example). When you have identified the sound as the dull noise which you have just now heard, press your finger promptly on this key." Figure 45 represents an accurate apparatus for producing the sound-object, recording the time of its production, and arranging for the character and the time of the movement which completes the action.

A characteristic set of results runs about as follows (in sigma) under the formal instructions given above; 260, 220, 200, 260, 200, 200, 240, 300, 200, 220, Average, 230; Mean variation, 28. [62]

When the reports of the observer upon the course of the action are examined, the following chief ingredients are found. (1) While awaiting the sound, the formal instructions are rehearsed, a bodily state of tenseness (especially in the finger) and general anticipation are apprehended, and self-instructions ('I must hurry,' 'Shall I succeed,' 'Do not let anything distract me,' and the like); (2) the perception of the sound, supplemented by an imaginational accompaniment, which takes the place, for the blindfolded observer, of a visual perception of the apparatus, the experimenter, and the general setting, together with a fleeting and dim anticipation of the finger-movement and the depression of the key; and (3) a vague perception of the moving finger, a comment 'That is done,' and an apprehended change of the tense bodily state into relief. With the reaction-times as given above, adequate reports would show that emphasis has been placed upon the anticipation of the sound and a careful appraisement of it when it comes.

This form we may call (for want of a better name) the *ap-*

prehensive action, because apprehension plays a conspicuous part in it. When emphasis is laid upon the moving side of the occurrence, with little responsibility for the exact character of the sound, the times are shorter (about 120 sigma). This type of action may be called *the muscular or motor action,* because the movement side is more prominent. The same result comes out in the two cases; but the relative prominence of the perceptive side (in the first case) and of the motor side (in the second case) shifts. Since the whole performance is very brief, every possible device for teasing out the stages of the action has to be used. One device is high practice, the trained observer coming in time to report all the functional details with great care. Another device is fractionation; the observer doing fifty or a hundred trials in which he reports only upon the preparation, a like number in which only the middle stage of the determination going forward is cared for and reported on, and another lot of trials centered upon the subsequent stage of the actual movements. Many thousands of simple actions of this sort have given the psychologist a clear and microscopic account of the entire course of these fundamental actions. Let us look at their counterpart in daily life.

The apprehensive kind is illustrated by the picking up of a piece of toast when it has been suitably browned in the breakfast toaster. It is only the clear apprehension of the well-browned piece that sets off the determination, though the entire function may have been thrown into commission by hunger, the breakfast setting, and the preparations for toast-making. Here occasional instructions may take the place of the formal kind in the experiment, unless one is specifically commissioned for the task. The function is more than the mere perceptive apprehension of toast. Besides a preparatory stage leading to a specific performance, the action is carried through its course by a determination (doubtless effected by a sustained integration of cerebral and other tracts). The de-

termination appears as a prophetic anticipation of the well-turned toast, removed, buttered, and served.

This running ahead of the present—which we found in the most primitive form of imagining—, with the organism coming in as 'actor,' is the hall mark of actional functions in their simpler but complete form. The apprehended object, scene, or event appears in action, then, as *an occasion*. It implies an anticipative change in which the acting organism is already involved in an executive way. Acting has this quality of reaching forward and entering upon the course. *The organism is incited to do*. But before it can really act (not simply move or 'respond'), it must have developed a primary form of restless and searching anticipation. Then when this anticipative stir is united with apprehension, there appears the determined and directive action. The searching aspect is magnified when the course of the determination is not wholly clear;—as when one is to put the buckle-tongue into the eyelet of the belt as soon as the hole can be found.

The daily counterpart of the motor form of the reaction-experiment is not difficult to find. It is, in the first place, poor in search, for the more pronounced the search the greater the scrutiny of the occasion for acting, and the greater the emphasis upon the 'sensory' side of the performance. We commonly act in the abbreviated, motor way where the action is touched off easily and promptly by a familiar occasion. When, for example, a car approaches or a windblown hat rolls toward one, but little scrutiny is required. The movement-apparatus is then set on a hair-trigger. A fleeting glimpse of the situation suffices. Movement is immediately anticipated and thereupon carried out. The frequent necessity for prompt and invariable action puts a premium upon this form. Instead of taking time to discern the situation and what it calls for, the prepared organism apprehends in a flash and at once makes the appropriate movements. Here many inventive de-

vices hint to the organism just what is to be done and so simplify its actional problems. The inviting handle upon the teapot, the knob on the door, and the directing arrow upon the road not only indicate conveniences; they come to be occasional instructions of great speed and accuracy to save the earlier time-consuming stages of the more elaborate sensory form of action. As regards functional modifications, they come under the headings of elimination, ligation, and stabilization. [63]

In our simpler performances we generally incline in the one way or in the other. When we have to fit our actions to the particular nature of some object, person or event, we perceive clearly and we unite the determination with the perception; and when the action needs only a hint from the object or event, we act trigger-wise with a fleeting or a vestigial perception, and at times upon the bare hint of an undefined change. As a general rule, the better we become acquainted with our accustomed surroundings and with the appropriate movement for a given occasion, the more the perceptive side is abbreviated and the more surely and promptly the action develops from a delicately adjusted determination.

Not always, in these typical actions, is the apprehension perceptive. This morning the sudden downpour of rain recalled my open door upon the balcony, and I jumped from my study chair to hurry home. The remembrance touched off a determining tendency and led to movement. Frequently anticipations release prophetic actions which provide against the immediate future. The same executive end is attained by way of imagination of the fictional kind, as when a bit of poetic construction leads me to reach for my pencil that I may record a fugitive inspiration. All of these actions, however, bear a family likeness. The core is an apprehension of some kind which is imbedded in a prepared central trend and which ultimately issues in appropriate movements.

A variant of this type of action is *the actional train.* During the World War the Air Service used, to determine the sustained performance of the aviator, a bank of miniature electric lamps which could be lighted one after another in a chance order. The flyer was instructed to make an appropriate movement the instant each light came on. This movement put out the light. He performed a chain of actions with a single instruction, *i.e.,* under a single continued determination. Each perception had to be clear and each movement led immediately to a new perception. In industry, again, the attentive guarding of machines, which momentarily shifts the task to a new movement, calls forth this kind of action, an action which is a progressive adjustment, through movement, to unforeseen changes in the surroundings.

In this new integration of a series of actions which had previously been distinct and independent, the formula for the function suffers the following variation.

(1)	(2)	(3)	(4)	(5)
Formulation of task	Progress of determination	Resolution and new apprehension	Progress of determination	Resolution and new apprehension

Here the issue of the movements (putting out the light) itself presented a new occasion for continuing the actional train. The schema scarcely does justice to the high integration of the whole train, for a common initial task often carries the performance right through its successive phases to the end.

The Automatization of Actions

We should give an incomplete account of our simpler actions were we to neglect the startling effect of repetition upon these functions. The novice at the piano or before the typewriter begins with the sort of performance which we have

described, simple acts and action-trains; but the performance soon changes. The first modification appears as a foreshortening. The perception shrinks. Individual notes upon the musical staff are no longer apprehended as individuals. They come in groups. Again, the individual determination which leads from this or that note upon the score to this or that movement toward the appropriate black or white key disappears. Along with this group-apprehension comes, without intermediation, a sequence of rapid movements. Still later, the score may wholly drop out of clear perception and serve as a vague and obscure cue to a complicated series of movements. The sound itself as it flows along may be the controlling object and then we have the curious instance of an activity where the perceived object is the result of action and not its antecedent.

This change informs us that the action is becoming automatized or self-sustaining. That means that the original perception is suffering reduction; that a single determination is holding together the entire, complete act and that it is almost or entirely without a prophetic coloring. We tend, upon full acquaintance with a situation (as under frequent repetition), to practice economy. Our living rooms scarcely call for perception. We take them for granted. Our actions in dining and in saluting our friends run themselves through with mechanical smoothness. We perform them without thinking, as we naïvely say. We find the station empty and the cabs gone and we know that the train must have passed; we decide without taking the trouble to argue the matter through. We see the sun on the left side of the car as we enter and so are spared the labor of discovering that it is better to sit on the right.

It is thus with all our functional accomplishments. The organism practices economy; it exemplifies the principle of parsimony. When the foreshortening reaches its limit under

repetition, the movement, which was earlier the final term in the action, may now become the initial term. It is immediately touched off without antecedents. We find it in the jump at a harsh command, the guarding duck of the head under a sudden blow, and the withdrawal of the hand from unobserved contact with an icy surface. These simple, direct, and highly specialized movements under stimulus suggest the physiologist's reflex. Although they may have high significance for the organism, they stand as a limiting case in our class of actional functions.

These telescoped and highly consolidated actions illustrate nearly all of the modifying stages and forms of our last chapter. Factors are eliminated, new ligations are formed, substitutions are made one after another, one grade of stabilization follows another, and consolidations of simpler and simpler form are effected until many of the marks of an actional function have disappeared (task, apprehension, determination, and resolution). Almost (but not quite) could the functions be handed over to the physiologist for description and factoring. One difficulty in such a transfer would lie in the fact that the physiologist is hardly prepared to manage any bodily operation one-half so complicated as the rapid and expert playing of a pianist or the winning of a great tennis match. 'Not quite,' again, because psychological functions are still present—however far they have gone in form and sequence from the simpler chains of the simpler actions. The expert performance upon the piano or violin somewhat resembles, as regards the functions employed, the reading aloud from the page. Here too the relations between individual tasks and the individual movements of mouth and eyes involved in the reading of the letters and words have quite disappeared. It is a closely-knitted and long-term function which is remotely initiated and remotely controlled, very much as we found our tennis-playing to be.

The fate of these extremely expert and finished operations is—as the fate of many highly habituated performances is—to serve as an accompaniment to other tasks and to other employments. The reader is absorbed in the sense: the musical performer is absorbed in the music. The performer's own part in the production of the substance read or of the musical object re-created is more or less incidental. The expert musical performer may still flatter himself by his virtuosity; but the artist is more likely to lose himself, as an agent, in exhibiting the work of an original creator. We shall have to return to this kind of highly automatized performance when we have fortified ourselves with fuller knowledge about other classes of function which still lie ahead of us.

Nowhere is this tendency to cut corners, to abstract from detail, more striking than in action. Wherever we can act automatically we save time; we save friction and labor, and we save our energies for other tasks. If we had to dress and breakfast each day with care to all details, we should not begin the real work of the day before noon. Especially is the process noteworthy in those executive trains which result from long practice in what we have called *skilled actions.* Thus the juggler who maintains several balls in the air with one hand and the cashier in the department store who makes change for a dozen counters. Here the foreshortening has a double source; the perceptive functions are reduced almost to the point of elimination, and the determination is set to include a whole series of successive acts, one phase following upon another. The same process of reduction and abstraction occurs in the performance of the trained animal which comes to respond with precise and inevitable movements to the faintest and most fugitive perceptive cues from its trainer. The uninitiated onlooker marvels at the 'intelligence' of the educated horse or dog, not realizing that at the end of its tuition the animal is not even perceiving. For such skilled

accomplishment, it is only necessary that some outside change should so affect the organism as to touch off a specific determination toward the appropriate movement. All the sagacity and intelligence lie in the trainer, not in the automatized animal.

Equivocal Actions

But action does not always run so simple a course as we have described. We started with the integration of the perception and the determination and we have observed the abbreviations of this executive form at various stages of condensation and ellipsis. Now we must observe that the executive functions also take more elaborate forms. Compare the selection of a seat in the street car with the dropping of the nickel in the conductor's box. In dropping the nickel the perceiving of the box determines the action and leads to the deposit of the coin. But in selecting the seat something else is injected into the action. One may—we will suppose—sit right or left, outside or inside, before an open window or over a heating coil. That means that the apprehension of the place will not immediately lead to one single set of movements. Choice implies that two or more possible determinations tend to complete and to extend the performance. So at table, if I am not quite certain of my tools, I may begin by using a dessert spoon or a bouillon spoon. On the road, I may take the right turn or the left turn. The case seems equivocal.

Now what happens to the executive functions in such cases? Well, the easiest way out is to be prepared or primed for the one action or the other. That is to say really to avoid a choice. For many emergencies we are so prepared, and then the choice is only apparent. One may, for example, decide that, while the heat lasts, only the shaded car-seats are comfortable or that one must sit outside for health's sake. After that the

rival determinations are killed. Only one seating place is considered. Behind many actions which would otherwise be equivocal lie many special rules of this kind. We decide that the 'eastern side of the street is best,' that 'good manners prescribe the place of honor for the guest,' that 'the small table in the corner at the club is the most comfortable nook,' that 'chocolate at breakfast is better for us than coffee,' and so on through the day. We constantly rule out alternative actions and so avoid the trouble of making a choice. Many times it is just this pre-decision set down as a rule which gives to our actions the appearance of freedom. There seems to be a deliberate and arbitrary choice when no choice at all—in the sense of a double determination—actually exists. But we now leave these false choices aside to examine the case of true double determination.

Action with Double Determination

The movement side of the either-or actions and the determination behind the movement have been studied in the laboratory. Two objects, *A* and *B*, are to be presented in irregular order and the subject is instructed to move (say) the right forefinger if *A* appears and the left forefinger if *B* appears. Here we have not, to be sure, a complete choice, because *A* determines one movement and *B* the other. The triumph of one determination, as we may say, is not left to the organism; it is rather foreordained by the instruction and the perception. So it is akin to the false-choice-by-rule, which we have just now examined. But the two determinations thus brought close together present an opportunity for observing certain aspects of this type of action. The action is variously initiated in the preparatory period while the subject awaits the object *A* or *B*. For example, there may be general tendinous strain which means 'here (at fixation) something is to happen and then appropriate movement is to be made'; or

both hands and arms may be innervated and the resulting tactual and kinaesthetic perception may mean 'I am ready'; or 'A-right—B-left' may be rehearsed in inner speech. With increased practice, as usual, the organism simplifies the task.

There may be, then, in the first stage of the action, only a vague intention, sustained by a tense posture of the body. Here, we must suppose, a sort of hypothetical determining tendency forms in the central nervous system which provides, without corresponding perception or comment, for the appropriate movement of the finger. So we have the two issues provided for in the one neural tendency. In the next stage of the action occurs a perception of the object, A or B, along with the determination 'right movement' or 'left movement.' With practice the perception becomes more fleeting and less clear. The purely physiological determination directly provides, then, the impending movement. This kind of either-or determination plays an important part in our manual operations which are not wholly mechanized; and in the reading of music, the use of the typewriter, and the give-and-take of tennis appear long temporal chains of automatic movement which began as separate disjunctive acts of this alternative kind.

To make a real choice we have only to provide an impromptu determination to replace the prescribed either-or. Thus when I observe among the new books at the library a volume by Joseph Conrad and a recent work on Prehistoric Man, both books attracting me, I have the materials for choice. I may take either. The determination which leads me to carry off the Conrad has somehow to take into account also the anthropological work. What now is peculiar to this selecting execution?

Look at typical experiments. I provide two numbers, 8 and 2, upon an exposure-card, and I instruct my observer that "A card with two numbers will appear. When I call 'now,'

decide whether you will add the one to, or subtract the one from, the other, or simply do nothing. When you have carried out the operation call out 'yes.'" A characteristic comment is 'addition' or 'subtraction,' contrived in various ways by the observer, as he perceives the place where the promised numbers are to appear. There is also a forward-straining and expectant search. Upon exposure we find a perceiving of the numbers and the operations ($8 + 2 = 10$ or $8 - 2 = 6$) accomplished also in form of a comment. Upon practice, the result 10 or 6 is likely to appear immediately. In these cases, whether the self-command 'add' or 'subtract' instructs seems to be due to the relative strength at the moment of the two corresponding functional tendencies. It appears from the experiments that the one mathematical procedure occurs about as frequently as the other, indicating that the tendencies are of the same order of strength. The potency of this determination is shown by giving in hypnosis the instruction, "When two numbers are shown you on a card give the sum (or difference)." The numbers are then shown upon awaking and the person immediately calls off '10' (or '6') without running through the operation and without knowing why he should so respond.

In these simple cases of choice we seem to have on the side of the executive functions no essentially novel factor. We have said that determination is a mark of this whole class of functions. The later stage of the operation is set or determined by the earlier. In the various sub-forms of the apprehensive action the movement is determined either by the perception itself or (as in the experimental setting) by formal instruction. Again, in the false choice, we find the determination set by a rule; in the partial or incomplete choice by a hypothetical neural process, and in the real choice by the possibility which is realized under the stronger functional tendency and which, once realized, creates a deter-

mination to add or to subtract. It might be thought that the 'add' or 'subtract' simply carries through the exposure-period guiding the appropriate operation. But there is no evidence supporting this supposition. The command to add does not linger and re-echo. The operation is really a new stage in the whole function, being the functional outcome of the earlier stage. The progression seems to be a characteristic sequence of this kind of performance.

When we come to what we commonly call our 'voluntary' actions, we find, as we might expect, that the everyday cases are somewhat more complex than the experimental. Even the choice of the Conrad or the Prehistoric Man is likely to be. Thus the carrying off to the loan desk of the Conrad may be preceded by such comments as 'I liked his last,' 'a good deal has recently been said about primitive man,' 'what attractive illustrations,' 'the Conrad will be taken out before I come again,' and so on and on, each one of these accessory operations now favoring the one main functional tendency, now the other.

Of course I may take the case right out of the choice class by a private rule, 'I take only fiction from this library' or 'I have no time for novels,' and so make the determination unequivocal. To be sure, even rules are broken. Were they not, conscience would have few terrors. They are, nevertheless, our main dependence when we wish to avoid the hazards of choice; and we find all manner of sanctions—social, religious, ethical and aesthetic—to fortify them and to place them beyond the reach of rivals.

Another way in which choice is complicated is by the appearance of hindrances to execution. When, in the experiments on choice, the determined comment was 'subtract' and the numbers then fell out 2 and 9, the impossibility of taking 9 from 2 checked the discharge of the determination; so with dividing the numbers 5 and 4. The same check appears when

we determine to leave the open fire and go out in the storm only to discover that overcoat or umbrella has been mislaid. Where the functional inclination is of sufficient driving power it survives the delay or the check. At times it is necessary to reënforce it by supplementary considerations, as in a crying need for exercise or the shame of submitting to difficulties.

Resolved Actions

Determination with a deferred goal is a resolution. It is an executive provision against the future. Two means of entertainment for the evening occur to me. One takes me up the hill and the other into town. Now I have decided upon the theater and I see myself (anticipative apprehension) turning down the street after dinner. Unless matters shift during the rest of the day, my resolution will be sustained and the theater-goal will be reached, without further interference. These deferred executions are among the greatest achievements of the human organism. They lie dormant while other functions run their course, emerging for discharge only when the appropriate setting appears. They emerge in post-hypnotic suggestion of an executive sort, their only peculiarity there being the lack of memorial recall for the original conditions of choice. But in normal waking life, too, this amnesia is frequent; only there we usually hide it by a process of rationalization which provides a specious explanation for our performance.

We should give the determinations of choice more than their due did we not reflect that very many of our acts are the outcome of habitual tendencies, of drilling in by modified repetitions; and not at all the outcome of rival motives. On the other hand, we must observe that human accomplishment goes far beyond that of other animals largely because man is able, by the nature of his anticipative apprehension and his more abstract intents, to determine novel performances and

so to attain new ends without an indefinite process of trial, failure, and modification. But this sort of performance leads us on to problems which we reserve for another time.

In all of our actions, but especially in our choices, we must not overlook the factor of bodily tuning. Who does not know the effects of fatigue, of hunger, and of general discomfort upon determination? Religious persecution has often resorted to starvation to break the resolution of its victims. A story in *Adventure* of an Alaskan blizzard in which the traveler was lost for days portrays the decay under weakness and cold of the determination to exercise and to combat the storm. It now appears that our determinations may also be exposed to change and decay through excess and deficiency in certain glandular resources of the body. It is possible that a change in a secretion in thyroid, ovary, or pituitary may so affect the central nervous system as to depress one whole group or system of determinations and to exalt another, thus changing the temper of the individual's actions and the social character of his conduct.

Willed Actions

Our descriptive account of action should help us to understand what we mean when we say that we *will* such and such an end. The secret of willing lies in the fact of determination. "Look for a red square," so the laboratory instructions run, "and lift the right forefinger when it appears." These instructions create a determination and by virtue of this determination the red square, when it appears, is apprehended as the thing prophesied in the instructions and the appropriate movement follows. Now suppose that, instead of instructions so imparted in the experiments, one is determined through choice. The operation is essentially the same, as we have seen; but here the determination may emerge as *my intent.* The action then is referred to the self-object, which—like every

other object—is a product of the psychological functions. The determination then operates just as any other determination would, but because it involves the self-object we call the act a 'willed' act.

Any circumstance which leads to the significance 'my determination' is sufficient. Thus the application of a rule or of a formula as 'the unselfish course is always to be taken' or 'good taste requires a polite performance' or 'this would be right' may so promptly set up a determination that rival considerations (necessary to a real choice) do not enter the field. At times the individual has nothing behind the stern fiat of his 'indomitable will' except some verbal formula, such as 'my way is right' or 'this is the command of God,' to support his determination.

We may say, then, that any action in which the determination incorporates an instruction which involves the self-object is a willed action. Of course, this designation only states a fact, it offers no substantiation for the common belief that, when one wills, a personal agent at the moment rules and dominates the organism, adding a power which the organism does not possess. We can easily see that such a belief is extremely gratifying to man's love of power and also that its moral implications are weighty. At the same time, we have to acknowledge that unbiased observation does not discover such an arbitrary ruler—one who does not derive his powers from the organism slowly fashioned throughout a long period of personal and racial history.

We could, of course, substitute a kind of biological teleology, as the behaviorists sometimes do, and speak of the organism as adapting or adjusting itself to conditions by 'responding to the demands of the environment.' But this procedure has two scientific defects; the concepts of response and adaptation substitute the behaviorist's interpretation of natural facts for the facts themselves, and the method employed ignores that

aspect of action which is most amenable to our direct and immediate observation.

What we do seem to discover, when we project the willed actions and resolutions upon the general background of life, is that they mark a distinct advance in the increasing self-sufficiency of the organism. The sponge and the oyster take their setting in life as it comes, directly reflecting in their physiological processes the state of the medium in which they are bathed. The acquisition of receptors, of a nerve-net, and of a digestive cavity is a long step toward self-determination or *freedom;* the securing of central adjustors and synaptic valves is another; the prophetic and telepathic eye another; the distinction of present, past, and future still another; and the actional determination, which includes the organism's past and may use to great advantage the self-object, is one more important event of the same order in the general history of life.

The Bodily Resources and the Government of Action

Our account of the bodily devices and processes which sustain the three main varieties of apprehending was not satisfactory. At many places it ran upon the limits of physiological and neurological knowledge. For the actional functions our knowledge is still more defective. The engagement of the motor nerves and the musculature is, of course, primary; and here the biological sciences have of late greatly advanced their understanding of the details of muscular contraction and of the processes of incitement from the nerves. What we especially need for the actions, however, is a physiology of the determination, *i.e.,* of the mechanisms by which a functional inclination in the central nervous system is made up and sustained while the action progresses on its way toward movement. In the brain there is doubtless a specific harboring and use of energy, which is integrated, on the one hand,

with the central processes underlying apprehension (of whatever kind the particular action involves) and, on the other, with the orderly and systematic use of the mechanisms underlying movement. It certainly is not so simple as a hierarchy of reflex circuits directly connecting the receptor with the muscle-fiber. That sort of explanation scarcely suffices for the activities of the earthworm, to say nothing of man. Beyond that kind of explanation, we have theories of central function but nothing which commands general assent.

With respect to government and control, we have already made many comments. Such a function as the determined function of action surely demands guidance. From our remarks upon government in learning it has become apparent that all three sources are brought into requisition here also. Both of the external sources (the great world and the human influence) are obviously governing factors in controlling for the organism the scenes and occasions upon which the actional determination is set. Without the well-attuned organism itself, however, these outside governors could provide guidance only to the most simple and separable form of action, where only one strong appeal at a time is made to the movement apparatus of the body. Even simple tropisms demand local arrangements of a reflexive type, and these vary in state and tendency. In the human adult, it is obvious that acting is mainly guided and conducted to its appropriate conclusion only by a central nervous system that has undergone a long period of functional tuition throughout the years of childhood and youth. Since we cannot accept a special governing center of unlimited and arbitrary powers or a more imperious will, we must still look for highly patterned processes within the brain which sustain and guide the nascent determination toward its ultimate outcome. It is clear that such processes could be prepared and kept going only by appeal to the long history, both biological and biographical, of the organism.

This historical source must be set down, though it is impossible at present to factor it (unless we descend to the unconscious), in terms of its origin and of its means for influencing and directing the various forms and complexities of human action.

CHAPTER VII

EMOTION

Emotion and Action

The kinship of emotion with action is apparent to everyone. In fear we run, we tremble, or we fall down; in anger we strike back; in rage we wave our arms or rend our adversary; in joy we dance and sing. Nevertheless, it is common in psychology to distinguish emotion and action as two separate classes. Can this distinction be justified?

Actions are not—as we have contended—mental states, conscious processes, or any other kind of existence that can be photographed or inspected. They are characteristic performances which are mediated by the body. They belong to the executive functions. They are characteristic ways of doing which lead up to and issue in bodily movement.

Emotions also are performances of the same general tenor. They are no more 'in the mind' than the operations of the steam hoist are a part of the engine, pulleys, or crane. Neither are they in the body. Emotions are events. They make particular use, to be sure, of bodily resources; but as emotions they are operations, occurrences, functions.

The primary difficulty in setting off the emotive functions from acting is due to the overlapping of the two classes. We have emotive actions, such as the sudden embrace of long separated friends; and we also have action-like emotions, such as those described in the tale of *The Lady or the Tiger?* and in Elizabeth's signing of the death warrant of her Scot-

tish kinswoman. These emotive actions and these 'active' emotions seem to suggest that the two functions are closely related. The truth is that emotion is just a modified action. The modification lies in two directions; it affects the *determination* and it affects the *resolution* of the action.

The Emotive Predicament

The most obvious thing to be said about the emotion is that it involves a *predicament.* It is commonly an attack, often unpleasant, upon the organism. This peculiarity we remark when we confess to being seized by fear, overcome by grief, harassed by uncertainty, carried away by rage, and beside ourselves with joy.

Let us scrutinize the matter more closely. First, as regards the apprehensive side, we speak of the *emotive situation* and we thereby imply that more than a simple apprehension of a single object is involved. An entire scene is apprehended. I am reproached by the traffic officer for bad driving. I suffer chagrin. The scene includes the crowded crossing, blocked motor-cars, the clang of bells, the rasping voice of the chiding policeman, my unhappy plight, my attempt at justification, and my self-reproach. I am in the situation and overwhelmed by it. The apprehension is both extended and vivid. The attack from the outside is complex—eye, ear, and other organs of sense are variously appealed to;—and inside, the central nervous system and the autonomic, glandular, and motor mechanisms are suddenly disturbed or augmented in function. Unless I keep my head, the chances favor an interruption of those coördinations which govern the car. I may, of course, continue the train of automatized movements in spite of the emotion. That is to say, I may reserve from the emotive seizure certain executive functions which serve to remove me from the crowded corner. Even so, the emotion continues its course, only to die a slow death

within the next half-hour. At the worst, I am overcome by a situation calling for resources which I cannot command; at the best, I carry through my action-train in spite of the emotion which continues its course and gradually disappears.

The tendency in emotion, then, is to frustrate the determination and so to check the appropriate movements. Whereas the action-determination gradually forms and prepares for its own resolution in movement, the typical emotion, through its general appeal to the organism, replaces or disturbs the determination, which continues then an abortive course to a different sort of ending.

Since the emotion takes this abortive course, at least so far as the determination and its motor outcome are concerned, we may ask why it does not destroy the organism. One reason is that many emotions which are connected with the most serious situations or predicaments of life—mating, enemies, care of young, and social encounters—release determining tendencies very old and stable, which involve the organism at large, and which therefore withstand the shock of the seizure. So the emotive incidents of mating, so the fright and flight before enemies, so the ancient devices for feeding and protecting the offspring, so the give-and-take between members of a group. Wanting these fixed previsions against the predicament, the organism would obviously be swept away or at the least incapacitated when it is not in a condition to form new determinations appropriate to the moment.

A second consideration is that emotion frequently dies out or it is superseded by other concerns of the organism. Grief crumbles before time, and remorse before the stern necessities of living. And, again, it is obvious that although an emotive seizure does not actually destroy the organism while in course, it may, when it persists unduly, lead on toward the afflictions of the neurotic and the insane.

The utility of the emotion, though much dwelt upon, is scarcely of psychological moment. Still we may note in passing that, on the side of actual accomplishment, the chief value of the emotion—at least for human beings—seems to lie in a social direction. The emotion has, that is to say, a significance for other members of the group. What we call the *expression* of the emotion obviously serves companions and the community in a very useful way, giving notice of the state and temper of the emoved individual.* For predicaments are of concern to one's fellows and companions. Human adjustments which do not take them into account are likely to be disturbed. In a secondary way, the 'expression' of emotion sometimes serves the organism itself as a safety-valve, discharging tensions which are incident to the predicament. In the government of emotion it is important that the individual learn to control the expression, as well as the underlying predicament itself. Emotions are expensive. They make a heavy draft upon man's energies. There may be compensations, as Cannon, Crile, and others have argued in the case of disturbed animals, where an increase of adrenin and other glandular deposits in the blood may momentarily augment the fighting chances; but these compensations would seem to appear only in a few of the grosser emotions which are closely allied to our simpler actional trains.

In human beings, where predicaments are most complex and most varied, the chief value of 'the expression' is certainly its indication of the state and temper of the individual as realized by others—by those others for whom the emotion is significant because they too have been in predicaments and have been 'moved' in a similar way. To be sure, certain levels of culture demand a repression of the signs of many of the emo-

* Cf. p. 19. We remark again that the want of a familiar verbal form leads us to revive the obsolete "to emove," which stands to 'emotion' as 'move' to 'motion.'

tions; but then these peoples defend themselves by rules of conduct, by verbal surrogates for the primary signs, and by providing religious, literary, and artistic avenues of outlet. How important a part emotions play in the group we shall better observe in our studies of social psychology.

Leaving out the intermediate functional forms, then, we may say that whereas the action is characterized by a determination, discharged in due course by movement, the emotion is characterized by the predicament—a situation in which the individual is so involved as to call for a resolution. Our chief task in emotion, then, is to study the predicament, its initiation, and its sequel.

The Sources of the Predicament

When we say that we 'fall into the emotion,' we seem to imply that an emotive situation is ready at hand to attack us from the outside. The fact that we often 'fall' without any warning also suggests that the source of the emotion lies without the organism. That is not quite true. The real preparation lies within the organism. The fearful, dreadful, or remorseful situation receives its characteristic *quale* only when it is confronted by an individual who is primed and prepared to fear, dread, or regret. Some men have contended, to be sure, that we all start with a small number of innate or instinctive emotions—fear, rage, and love, form a famous trilogy of these alleged inconveniences—but when we put the predicament at the center, it becomes obvious that we cannot emove except in so far as we can apprehend a predicament.

When we come to consider the functions of the newborn child we shall find no organic or behavioral evidence that any form of apprehending is innate or connate, and much less hereditarily derived from parents or race. There would seem to be no better reason for believing in innate pre-

dicaments than for believing in innate ideas. What does go back to prenatal life (not to parents or race!) is the completion of organic contrivances for carrying through certain characteristic writhings, postures, and facial contortions which suggest to the credulous physiologist and behaviorist the 'expressive movements' observed in adult emotions. We can forgive nurse and parent for inferring that these are social indicators which demand soothing, food, or other means of consolation; but the ready and romantic inference of the scientific investigator of infantile life is not so easily condoned. What we actually observe is that certain contrivances are at hand soon after birth and presently made use of to give color and 'expression' to actual emotions but *only when the organism is prepared to apprehend occasions and situations which make a predicament possible.* To fear, dread, or love demands a feared, dreaded, or loved object or situation. To this end, perception (or memory or imagination) must be functionally possible and also (since a determination is bound up in the emotion with the apprehension) an integration of an apprehending with an incipient determining would seem to be involved before emoving can be undertaken by the child.

The order of these infantile events we shall work out when we deal historically with the young child in our developmental sequel. Here we only observe the necessities on the bodily side for this second form of executive functioning. What we really have at hand in these alleged 'loves, fears, and rages' of the baby is a certain part of the bodily equipment for throwing the body into turmoil when the emotive occasion finally comes to hand and when the appropriate psychological functions and their government have been worked out by the organism.

When the first emotions do begin to run their course, we find—just as we found in the case of repeated functions of

the apprehending and the actional kinds—that the various factors of inclusion, substitution, ligation, elimination, and stabilization appear, to extend, temper, and remold the emotive predicaments and their outcomes. All these factors we shall have to substitute for the more naïve conception of 'conditioning.' Here we remark that emotive exercise, as thus modified in all these ways, leaves upon the body *a specific inclination* toward future functions of a similar kind. The specific inclination will be colored and tempered by the life-course of the growing organism, as directed by the influences exerted through parent, nurse, teacher, and associate. These are the 'springs' of emotive activities. They are 'dynamic' in the sense that the emotion runs its active course according to the specific inclination at hand when the emotive occasion presents itself.

The predicament, then, is not passively suffered. It is rather in the organism than in the objective play of circumstance. That is to say that the organism is so primed and inclined that a given situation becomes a predicament. One and the same scene or person may precipitate a passionate crisis in a lover, a gust of hatred in a business rival, envy in the victim of misfortune, and fear in the timorous. These individuals are differently inclined and so create different predicaments out of the selfsame encounter.

The inclinations stand to the emotion much as the specific neural tunings stand to the action. In the normal, governed individual they precipitate a crisis only upon suitable occasions. The individual is angry, fearful, jealous, grieved, or joyful as the occasion suggests. The occasion cannot, of course, be considered apart from the private history of the person seized and from his relations to the exciting object or event; but his emotive inclination is conformable to his circumstances.

Where the inclinations are excessive, one-sided, or unbal-

anced by opposing inclinations, the individual is emotionally erratic. The hasty man flies into anger upon any pretext; the coward is habitually inclined toward fear; the sentimentalist makes predicaments where only cool matters of fact are presented; and the melancholic person falls too readily into despair and discouragement. These emotive springs are important also for character. They determine not only the emotions. They affect the individual's actions, thoughts, and general outlook upon life. They are derived both from the individual's past, being commonly affected by health, sickness, success, previous crises, and habituated modes of creating and of dealing with predicamentive situations. Where the prevailing emotive inclinations of an individual are pronounced and persistent they are spoken of collectively as *temperament.*

The Functional Consideration of Emotions

Nearly every psychologist attempts to classify the emotions; but, like most classifications, the emotional species and varieties furnish dismal reading. No single classification has ever been generally agreed upon; in part because the experimental study of emotion is in a backward state (we have no adequate description of the factors involved) and in part because it has been easier to discuss theories and especially biological theories of origin and use than to distinguish classes and kinds. When we agree to regard emotions as functional modes we limit our classification to varieties of performance, just as we did in action. We have, then, to discard such logical schemes as 'objective—subjective,' 'self-referring—other-referring,' 'selfish and social'; and neither can we derive emotions from a few hypothetical instincts which are taken outright from biological speculation or from casual observation of other animals. If we shifted our conception and found the core of emotion in certain sensory components, as the orig-

inal James-Lange theory assumed, we could classify as visceral, thoracic, and circulatory, or as straining and relaxing, agreeable and disagreeable, exciting and subduing. These classes seem, however, to touch either upon incidents in the emotion or upon hypothetical origins rather than upon the varieties of emotive performance itself.

To understand the main ways of emoving, we must keep in mind our two large types of function, the apprehensive and the executive. First, emotive situations commonly imply—as we have seen—some form of apprehending. We notice that Jones smiled in a supercilious way when we expressed an opinion upon a certain matter, that Foster ignored us upon the street, that the motor-car was making directly for the pedestrian, that the sky was clearing in time for our outing, that *M* preferred the society of *T* to our own; so resentment, humiliation, horror, joy, jealousy. Thus apprehension plays its necessary part; it presents the *scenery* for emotional enactment. But it is not always of the perceptive kind. You are stirred with wistful longing when you remember better days, angered when you recall the insult, and flushed with embarrassment over a remembered gaucherie. Again, emotions are engendered where the apprehension takes one of the imaginational forms. Anticipation stirs, reveries thrill, and the creator of a work of art suffers and rejoices before his fictitious object. In all its forms, then, the apprehensive kind of operation contributes to the function. There are two or three things about it, however, which make it especially appropriate to the emotive setting.

The extent of the apprehension we have already remarked. Not a single object but a whole situation, with its internal relations, is apprehended. Again, the situation is *dramatic*. It is more than a mere scene. It works: it is dynamic. The persons and forces are aggressive; they insult, injure, comfort, aid, misjudge, and misinterpret. This aggressive char-

acter of the apprehension is due in part to its hallucinatory nature—even in the remembered quarrel or the imagined love-scene there arises the illusion of a vivid presence—and in part to the affective coloring which overlays, and is fused into, the apprehension. This dramatic presence serves to convert the situation into a predicament, into a problem calling for solution.

Once more, the situation usually involves the individual who apprehends it. He is a part of its significance. The fearful object threatens him, the insult touches him, he is grief-stricken or pitiful, resentful or jealous. Where the observer is not himself a dramatic part of the situation (as in an accident quite beyond his power to aid), the situation nevertheless seizes him and so demands a resolution. Finally, the apprehensive side of the emotion is (at least usually) of the symbolic kind. The reference is to something beyond the presented scene. Directly apprehended objects stand for, symbolize, something else. The uplifted arm means 'intent to injure,' the raucous voice that the 'other person is irritated,' the blue sky that 'nature smiles upon our outing,' and the collision on the street means 'death' or 'suffering.' This symbolism is of a valuing, appreciative sort. Through it we emphatically inject into the scene our own feelings and thereby enhance its dramatic character.

Predicament, Determination, and Search

We cannot complete our account of the emotions if we stop with the apprehension, for emotion is more than the setting forth of a situation. We have spoken of the aggressive, appealing aspect of this function, the aspect which converts it into a predicament. The situation makes a demand; it represents a need. But instead of a determination which issues in an appropriate movement, as in action, the emotion is resolved in a different way. In action the need progresses toward

satisfaction under the guidance of a determining tendency. Not so in the emotion. Here lies the nerve of the distinction. In emotion there appears a problem which is not immediately soluble through movement; a dramatic situation which is not removed by a thrust of the fist, by a turn of the body, or by any delicate coördination of eye and hand. It is not that sort of problem. In terms of the executive functions, a determination is called for; but no adequate determination, none fitted to the problem, arises. In consequence, the function of *search*—search for a means of resolution—usually plays a greater rôle in emotion than in action, where an appropriate end is commonly predicted.

Out of the unrelieved search arises a general organic crisis which varies with the character of the apprehended situation and varies also with the history of the organism. So we find unlike seizures for rage, grief, joy, resentment, fear, and other more pronounced emotions; and we also notice that the outward indications vary in the child and the adult, the adolescent and the senile, the European and the Hindu, the Northman and the Latin. Cannon concluded that the physiological mechanisms of the trunk were essentially the same in the various emotions; but Cannon's experimental observations were chiefly confined to visceral changes in animals under operative conditions whose state superficially resembled a terrified fear or rage in man. These changes chiefly concerned heartbeat, peristalsis, contraction of smooth muscle, and glandular secretion. There still remains the possibility of other factors in these and in other emotions, of differences in degree, in pattern of integration, and in various modes of somaesthesis. Even a superficial observation will discover gross differences in the bodily feel of postures, grimaces, and attitudes which are variously set to simulate fear, fighting anger, grief, cunning reprisal, and amorous conquest.

We do not suggest that the reflex or automatic bodily changes are the emotion. The strongest adherent of the James-Lange theory would no longer so contend. It is nevertheless clear that the organism does undergo complex changes which vary, at least in part, from emotion to emotion. Our apprehension of emotion in others, through mien, gesture, and other 'modes of expression,' as we say, testifies to this bodily diversity. These complicated organic changes help to represent in the bodily vehicle the specific problem which confronts the individual. Whether or not they are decipherable as *real expressions* is a question of great biological but small psychological significance. The fact is that they represent the bodily involvement at a certain stage, a stage which we have called the crisis.

What the central physiology of this stage is we know very inadequately. Bain spoke of a wave of diffusion or overflow. Cannon points to the thalamus. Whether the brain is surcharged with energy which suddenly breaks bounds and floods the central nervous system we cannot say. There are evidences that the central involvement is at least widespread, and that instead of the release of a specific determination which would lead on to a motor issue in action, the organism resigns itself, so to say, to an insoluble problem, vainly uses a wide variety of resources, and only gradually returns to a more settled state of function.

There can be no doubt that a large part of the difficulty which psychologists have always encountered in attempting to analyze emotions arises from the prominence in these baffling phenomena of an unanalyzable *indicatory aspect*. The seizure indicates an interference with the general progress of life, with those processes of metabolism, secretion, and so forth, which generally incline and temper the neural functions and which appear as pressing and restrained desire.

Classes and Varieties of Emotion

If we follow precedent, we may distinguish the emotions in various ways. The most obvious way is to search casually through our daily experiences and to set down as many striking 'emotional states' as we chance to find; thus love, anger, fear, sentiment for property, enjoyment of power, pain of subjection, pride, vanity, aesthetic emotion, moral sentiment, etc. (Bain). Such a catalogue is about as valuable to psychology as the truck-gardener's list of crops would be to the systematic botanist.

The names which we commonly bestow upon the emotions serve first to characterize the predicament in terms of practical common sense. Thus fear indicates that 'here is an object or state of affairs which threatens'; anger that 'this act or attitude must be protested,' joy that 'this turn of events brings what I want,' jealousy that 'this person receives that which I desire,' and so on with the others. The names serve, secondly, to characterize the gross attitude of the individual toward the predicament. On this side, fear means 'a shrinking, retreating, panicky condition under threat,' joy means 'the feel of triumph and celebration,' and jealousy 'defeat under competition.'

No classification which attempts to catalogue these functions by enumerating the predicaments can be satisfactory to the psychologist. That attempt would be like listing the parcels in the picnic-basket to arrive at a classification of their dietetic ingredients. Even the distinction based upon the organic state, the posture, or the expression touches only individual factors and accessories. A moment of terrible suspense may be followed by cardiac palpitation and general weakness; an insult by a respiratory stuffiness. There is the cold sweat of terror, the intestinal sinking in dismay, the thrill of gooseflesh, the muscular spasm in agitated uncertainty, the hopeless

misery of effort under a nervous fatigue, and the swimming, dizzy loss of balance when the last straw of trouble finally causes a general collapse. But these are all incidents in the seizure of the organism. [64]

Since the emotion is for us essentially a mode or way of functioning, our own problem of classification concerns this manner rather than the items which enter into its formation. Nothing like a definitive classification is to be thought of at this time. In fact, it is doubtful whether sharply delimited classes or species of emotion exist. All that we can attempt to do is to scrutinize the functions in course, indicating the various ways in which the predicament is formed and then resolved or destroyed. To this end, we shall do well to keep constantly in view the functional likenesses and differences presented by what we may call the complete and typical action and emotion. The similarities may be exhibited in the following comparison, which will indicate the likeness and the essential difference between the actional and the emotive varieties of execution. Because of the seizure in the emotion the determination fails and the function declines in an ineffective way unless some intercurrent diversion comes to the aid of the organism.

STAGES OF THE ACTION

Formulation of task	>	Progress of the determination	>	Resolution through movement

STAGES OF THE EMOTION

Dramatic situation	>	Seizure	>	Attempts at resolution	>	Decay and decline

Our emotive varieties should, then, represent modifications in course and variations in outcome. We shall distinguish the most important of these varieties.

1. *Emotions with complete want of resolution.* Here the predicament resists every attempt at solution. Every incipient determination ends abortively. The organism is helpless. The diffident boy is suddenly called upon for some small service in an observant group of his elders. He sits and gapes. He shrinks from being conspicuous. He does not seem to himself to be the appropriate person to discharge the task. At the same time he dislikes to be unobliging. He would like to explain. How can he? He grins and blushes. He cannot speak or rise. The task is impossible; so he miserably fidgets and suffers. Under other circumstances, the irresolvable predicament may take the direction of anger, as from an unexpected taunt or insult where a public protest is impossible. Here again the individual is helpless. Shame from a public exposure may take the same course. There the predicament paralyzes the organism. Nothing can be done at the instant, although the situation calls for resolution.

In this stage of floundering and searching for release, it is common for the seizure to mount in intensity. The stubborn knot in the shoelace may incite to profane exasperation; the insulting taunt to torture; the dreaded dentist becomes a monster; and the rival in love a hated fiend. In these cases the somatic involvement is widespread and intense. Smooth and striped muscle, gland, and viscus are innervated or paralyzed. The bodily commotion is violent. No action ensues because none really succeeds. The very formulation of an actional task miserably fails. The result is a gradual dying out while the organism continues to nurse the predicament. As a rule, failure brings on a crisis, and after the crisis the seizure begins slowly to subside.

This is the typical emotion which is implied above in the schematic comparison with the typical action. We may now examine variants from it, as we examined in the last chapter variants from the typical action.

2. *Emotion with incomplete resolution.* Instead of an initial helplessness, the situation may release a determination which, however, fails before it is completed. So resentment at a boorish action sets up in the nervous system a determining tendency which clenches the fist and starts a verbal reproof; but the necessity of repression extends the predicament, cuts off the determination half formed, stays the hand or the tongue, and leads to a general somatic excitement which induces the crisis. A gradual subsidence, instead of an appropriate movement, finally completes the emotion. The inhibitions of custom and manners often give our emotions this appearance of frustrated action.

This emotive course may be represented as follows:

Dramatic situation > Seizure > Inadequate resolution > Intensified seizure > Decay and decline

3. *Emotion following an automatized action.* Walking in the suburbs I suddenly find myself giving a startled jump into the air. The body is twisted to the right and the head to the left. A bicycle silently passing has turned upon the dry grass to avoid me. It is as if I had jumped to escape a sudden rustling in the grass; but the apprehension of the fearful object comes only after I have lifted myself off my feet. Before the apprehension fully develops, however, it is corrected by the sight of the speeding wheel with its amused rider. There is no doubt of terror with extreme unpleasantness; although it appears after the automatized movement has set in. Here we have an instance of the intermediate half-action-half-emotion which exemplifies the close relationship of the two kinds of executive function. An old determining tendency which leads on to the startled jump is effective before the apprehended situation arises; and the automatized action is so far under way that the delayed predicament does not interfere with it.

Automatized action > Seizure > Dramatic situation > Decay and decline

Some psychologists have been inclined to see in these seizures with automatized movements evidence of the racial or instinctive roots of emotion. This view is speculative. It is more likely that these sudden recoils and defenses have been transformed and adapted from a more primitive sort of spontaneous movement to the varied situations of the individual life. When these acquired automatisms have been allowed for, it may be that a few coördinations will remain in which the hereditary factor of stock has played an important part; but we are not justified in looking to instinct for the origin of the great number of emotional seizures which overtake the human organism.

4. *Emotion resolved through action.* Notwithstanding the resistance of the emotion to a speedy resolution, we all know occasions upon which an action may be imported for the express purpose of clipping short the term of the seizure. A stock example, popular in lurid fiction, is the evaporation of hate or jealousy through murder. While some men hesitate to employ such an heroic measure for relief, we all use the same device when we vent our spite by kicking the defenseless chair which has painfully startled us in the darkness. In these decapitated emotions the action cannot be said to be an incorporate part of the seizure itself. Rather it is an outside device which succeeds by destroying at one blow the predicamentive occasion.

Dramatic situation > Seizure > Attempts at resolution | (Action)

When we employ these drastic means of dissipating emotion, we often discover to our chagrin that the dissipation is

only temporary and that the old predicament returns to vex us, to vex us at times beyond the violence of the original seizure.

5. *Emotion with a train of active incidents.* The relation to action is still more intimate in those emotive situations which include a whole series of performances. Certain parental situations are of this character. They revolve about the infant. The mother is solicitous for care and comfort. During the course of a single emotion of this kind the movements necessary for bathing, feeding, dressing, holding, and embracing may run their course. In the emotion are embedded a chain of determinations which issue in sequence in the several actions. So, in fighting, a sustained anger or fear may lead to a train of offensive and defensive movements. The enemy is struck, dodged, tripped, and thrown; but still he is enemy. The expressions of joy, as in the sudden encounter with an old friend, may likewise occupy the same place. Here the emotion is primary; the several actions secondary and incidental. Primacy is shown by the fact that the predicament continues until the completed action-train finally resolves it.

Dramatic situation	>	Seizure	>	Appropriate actional trains	>	Decline through actional outcome

6. *The transformed emotion.* There is another way in which the emotion may fail to end by a gradual decline. This way appears in three variant forms. In the first, an incompatible seizure is kindled while another is in course. Then the first may be subdued and checked. We all use the device of killing one emotion by another. The parent supplies a novel form of entertainment or a familiar form of punishment to distract the child from his sorrow, disappointment, or sin. If nothing is at hand the child is promised a holiday, a present, or a whipping, which he is urged to anticipate. His elders likewise

seek out for themselves agreeable forms of entertainment or of dissipation to destroy worry or unrequited love. Since any predicament engages the organism in a general and absorbing way, it does not countenance a rival. Therapy makes good use of this principle of replacement in order to root out emotive trends which are too insistent or too exhausting. Emotions which reach out to irrelevant matters and so consume the individual for hours and days together are unhygienic. A worry or disappointment, for example, which gains control of the psychological functions at large, irritating the brain and gnawing at the automatic vitals, while it runs a long and violent course, is inimical to health.

In the second form, the change may be resident in the emotion itself, which shifts and changes instead of being replaced by another. What we call *relief* is really the resolution of anxiety, dread, or despair. The forward-looking, anticipatory predicaments are very likely to present this phase at the stage of resolution. I am anxious over an approaching operation. The anxiety turns to relief upon good news from the operating room. I dread an examination in history and I am relieved when it is over. In a similar way, joy may turn to anger, if the source of the joy is suddenly cut off. Even the good intentions of a friend who seeks to distract us from our sorrow may tempt us ungratefully toward resentment. Thus obstruction or frustration during an emotion, as well as at its resolution, may lead on to a new emotional phase. These emotions which pass through successive phases have been called 'temporal'; but all are temporal, because they all are functional operations which run their course.

The third way in which the emotion is transformed involves a change of circumstance while one and the same predicament remains. In Conrad's *The End of the Tether,* the ship's mate jealously hates the calm and dignified master of the boat; but later he gleefully regards the same man when he discovers

that he is blind and helpless. In a similar way anger may turn to hatred when the object proves to be invincible and hope to despondency where courage fails. A shift in the implication of the predicament leads to a change in the emotion.

In all these cases the breaking off in course results from a change in the dramatic situation. The general formula covering the three cases would be written as follows:

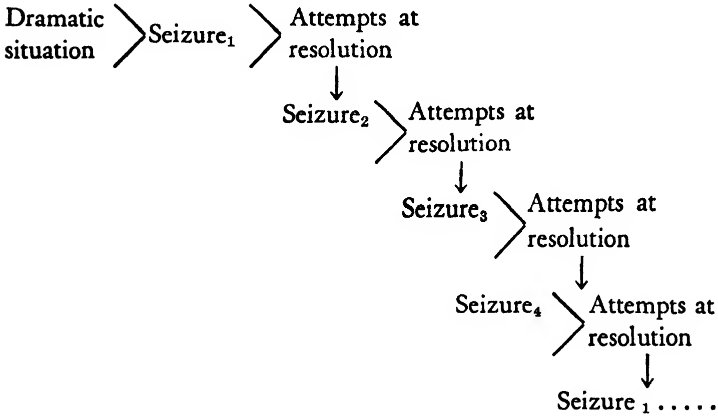
Dramatic situation$_1$ $\rangle$ Seizure

$\longrightarrow$ Dramatic situation$_2$ $\rangle$ Attempts at resolution $\rangle$ Decay and decline

7. *The emotive cycle.* Instead of a single shift or replacement in a dramatic situation, the emotively seized organism may cling to its predicament for hours, days, or months, looking at the situation now on this side, next on another, then on still another, without exhausting its dramatic possibilities. According as a man regards his misfortune, grief, or anxiety in this way or that does the temper of his seizure change and the bodily involvement change. We have all seen defeated men brood week after week over some emergency which had proved to be beyond their powers. They constantly advert to the matter in memory, examining it on its various faces and circling about it with emotional attitudes, regretting, then hating, then justifying, then excoriating, then sorrowing, only to come back to the first phase and so to run again through the entire cycle. When these predicaments touch the springs of life, threatening the economic, social, or professional standing of the individual, they may become, if unchecked, very serious, leading to permanent impairment of the functions. Failure in business or in a profession, excessive grief with remorse, loss of reputation, and the crises of battle, are productive of these vicious and dreadful emotive cycles.

The cycle is not always continuous. Hours or days may

intervene between succeeding phases, especially when the seizure begins to weaken. But the inclination is sustained, so that a new phase only awaits a hint which will revive and reinstate the cyclic activity. A steadfast friend who has seen an individual through such an emotional excess knows how slight a hint is required to set the afflicted person off on the vicious round. All the functional avenues of the organism, physiological and psychological, lead toward and into the dominating and enthralling predicament.



Emotively Toned Episodes and Trains

Besides all these variant forms of the function, we have to take account of a lot of daily performances which are emotion-like without being quite clean-cut emotions. Among these performances we may easily distinguish the episode and the train.

A greeting upon the street or the handwriting upon a letter in the post may induce the emotionally toned episode; and an hour's social call, the delivery of a lecture, or the attendance upon a concert, may establish an emotional train. The peculiarity of these states is that they are devoid of execution,

and they cast only the shadow of a predicament. Nevertheless, there is an affective unity about them which suggests emotion. In the episode, we have a highly socialized apprehension. The implications of the greeting dispose the entire organism. The individual glows, frowns, or condescends. Of course, the incident may develop a real predicament ('How shall I preserve my dignity?' 'I certainly hate him!' 'Is it too late to dodge?'); but we now consider only those cases where it does not.

In the emotively tempered train appears an entire *topic,* which we shall better understand when we come to the sections on comprehension. An extensive mass of material is bound together into a single subject. Those who speak in public know the emotional phases of the address; the plodding rise of the first minutes, the invigorating swing of exposition, the thrill of engaging the audience, and the lassitude of the end. The auditor, likewise, at the symphonic concert may sustain a similar train, bearing its own characteristic phases. At other times, it is in acting, instead of in comprehending, that we feel the emotive stir. In vigorous labor under obstacles the hint of a predicament charges us for the task. We must finish the job, though it taxes our resources of skill and strength.

Whenever we wrestle with nature, conquering and subduing as we go, our performances are apt to present this emotive coloring. The predicament sustains our interest, keeps us on our mettle, and so invests the daily task with vigor and enthusiasm. Again, artistic production, in so far as it involves execution, gives rise to this sort of emotive tuning. The proposed picture or sculpture is a predicament which the artist works himself through, under the glow of perplexity, dismay, and joy. It may be these episodes and trains which have fixed the common belief in agreeable emotions. Stir, thrill, enjoyment, pride in accomplishment, the lust of personal influence, and

the like—common meanings of the episode and the train—are undoubtedly conducive to pleasure.

Are Real Emotions Ever Pleasant?

The term predicament seems to suggest that emotions are always unpleasant. Most of them are. Take a representative list of them: anger, rage, fear, pity, resentment, jealousy, envy, grief, hope, hate, despair, joy, remorse, shame, disgust, relief, lust, anxiety, disappointment. Only hope, joy, relief, lust, and certain forms of anger suggest agreeableness or pleasure. Of these we may say that relief is but an agreeable resolution succeeding unpleasant anxiety, fear, despair, and the like; that anger is pleasant only when it is in process of resolution, and that hope is only hope when the predicament presents unpleasant possibilities. We are left with joy and lust. From joy we must subtract the joyful and playful moods (without predicament) and the joyful resolutions of a wide variety of unpleasant predicaments (the most frequent joys); and from sexual and amative emotions those frustrated forms which are distinctly unpleasant. We are still left with the real stir of desire before its object and the joy which inheres in a really joyful situation. But it may be doubted whether joy is really emotive. There are joyful occasions. But are there joyful predicaments? Shand argues for a kind of predicament or 'end' in joy, an end which he finds in the effort to maintain the joyful occasion, 'to conserve the existing situation,' to prevent it from lapsing; but it is doubtful whether this is an inherent part of joy itself. Where joy is not a case of exuberant spirits, a mood sustained by agreeable apprehensions, it appears essentially to rest upon unimpeded action and accomplishment, as in play, exercise, and the dance.

Some of the phases and situations of love fulfill the conditions of a pleasant predicament, the pursuit of the loved object and amative play. Here desire in suspense, combined

with some form of the apprehensive functions, furnishes the predicament, and bodily reverberations supply pleasant somaesthesis. But even in love a large part of the pleasant toning belongs to the stage of resolution and not to the earlier stage of predicament. The various forms and incidents of love should warn us against confusing a single emotion with a fixed attitude toward a person, object, or institution, which may supply the individual with a long and varied series of separate emotions. Affection, whether for mate, child, or friend, may yield, according to circumstances, hatred, jealousy, resentment, fear, anger, and sorrow. Almost as many emotions may be derived from a cause, a party, or a principle, according as one expounds, defends, doubts, or loses. In fact, it is questionable whether any object or matter which is capable of furnishing one emotive predicament is not also capable of furnishing others. These varied emotional resources, which Shand calls 'higher systems or sentiments,' have important social values, as we shall presently see; but they add little to our knowledge of the emotive functions themselves.

Mood

Since emotion represents, so to say, the tempering of the whole individual in a given crisis, we might expect that something like it would appear even where no situation forces a predicament. We do find something like it, as a matter of fact, without the predicament, and then we know it as mood. The irritant mood needs only an occasion to precipitate an angry explosion or a resentment; the timorous mood, terror; the jovial mood, joy; the melancholy mood, sorrow. Underlying the mood is a fixed inclination; an inclination which colors the whole stream of functioning, directing and diverting its course. A coöperative study of these moods in the writer's laboratory has revealed an enormous variety of them, half-a-hundred of them being reported by six observers. It

appeared that these moods were present during a large part of the average day; and that they were due to, and were sustained by, digestive processes, general kinaesthetic tone, intercurrent emotions, work, recreation, sleep and sleeplessness, personal encounters, fatigue, and many other factors.

It is in mood that we find most vividly exemplified what we call the 'vital indicator.' Mood registers the ebb and flow, the rise and fall, the hurry and retardation of life. Moods do not present objects and situations: they are essentially unpatterned: they are gauges set into the organism. It is not by accident that our salutations 'How do you do?' 'Comment allez-vous?' and 'Wie befinden Sie sich?' advert to these registrations, or that our small talk should constantly bear upon vital subjects. Health, our 'feelings,' our glandular balance, our digestive state, our muscular tone, our reserved energy, all are registered in our moods. Only the personal affairs of a man's neighbors and of the eminent can rival his absorption in his own intimate state of being.

It is inevitable that a phase of function so closely related to the ebb and flow of life should suffer in 'mental' disorder, and it is significant that the classical disorders of melancholia and mania, reflecting by an uncritical designation the most obvious swing of mood between elation and depression, should have played so important a part in the history of these disorders. Only the psychology of wish and desire has given a secondary place to the aberrations of mood. Again, we shall discover, when we come to study the socialization of man, that the interplay of men in groups is largely determined by mood and by the more permanent affective trends of disposition and temperament.

Emotion and Desire

We have found the directive and forward-tending aspect of life basal. Life does not go on at random but according to

definite trends and inclinations and in certain directions. This aspect of life we have found to be reflected—at least in man and other of the more complex animals—in a primitive kind of search, which appears at about the time of human birth. Afterward, when search has been informed by perceptive apprehension and by the simpler forms of action, search becomes a tending-toward the discovery of things and objects and a tending-toward the outcome of our actions. When this informed kind of searching is charged with feeling, we call it *desire*. Since search readily coalesces with all the psychological forms of functioning, we might well expect that desire would prominently appear in many of the phases of man's life. Especially do imagining, comprehending, emoving, and acting imply that straining-forward which not only constructs the world-to-be but also invents occasions for desiring and ways and avenues leading toward desire's satisfaction and appeasement. [65]

Bodily Resources and Government

Inasmuch as the course of the emotion implies both the apprehending and the actional functions, we may expect that the emotion will engage the body in at least all the ways that it is engaged in perceiving, remembering, imagining, and acting. But in addition to those widespread resources, we may ask whether the emotive functions do not make some special and additional demand upon the organism. At present it is the general impression among psychologists and physiologists that they do.

Two specific resources have been dwelt upon; the ductless glands and the autonomic nervous system. Indeed so deep has been recent interest in these bodily structures that many men have persuaded themselves that certain patterns of function in gland and autonomic *are* the emotion. Although most quarrels over definitions are futile, you will readily see that

any conception actually confining emotion to these interesting parts of our interiors must do entirely without such actualities as our being caught up in a demanding situation which leads to seizure, which places us in a predicament, tortures us while we try to escape, and leaves us to regain equilibrium as best we can.

There is no doubt that this sanguine emphasis upon these bodily structures—while it could not, for us, take the place of functional description—has greatly extended our knowledge of the part played in emotion by glands and autonomic. No occupation (not even hard thinking) calls so generally and so widely upon the body as does the kind of function called emotive. The very fact that the organism is brought to an *impasse,* with no adequate resources for coping with its needs, suggests that the bodily reverberations will be general and intense.

Now the part of the body most obviously brought into requisition in emotion is just that part which is primarily involved in acting; that is to say the neuro-muscular system. But while neuro-muscular activities are stable, coördinate, and of definite pattern in the action, they are instable, incoordinate, and broken in emotion, and the resulting movements are hesitant, inconsistent, and without definite issue. The emoved organism trembles, puts out helpless members, grimaces, and fumbles. Only in such emotively toned actions as striking and biting when angry and running when fearful —functions in which the body still controls its actional systems—is the organism competent in certain restricted vertebrate situations where adrenin flows freely. It is the general rule in predicament that the neuro-muscular activities should be incompetent and ineffective.

With this resource thrown partially out of control or else exercised unduly, as in the ordinary seizure, it seems to be inevitable that those structures which are intimately connected

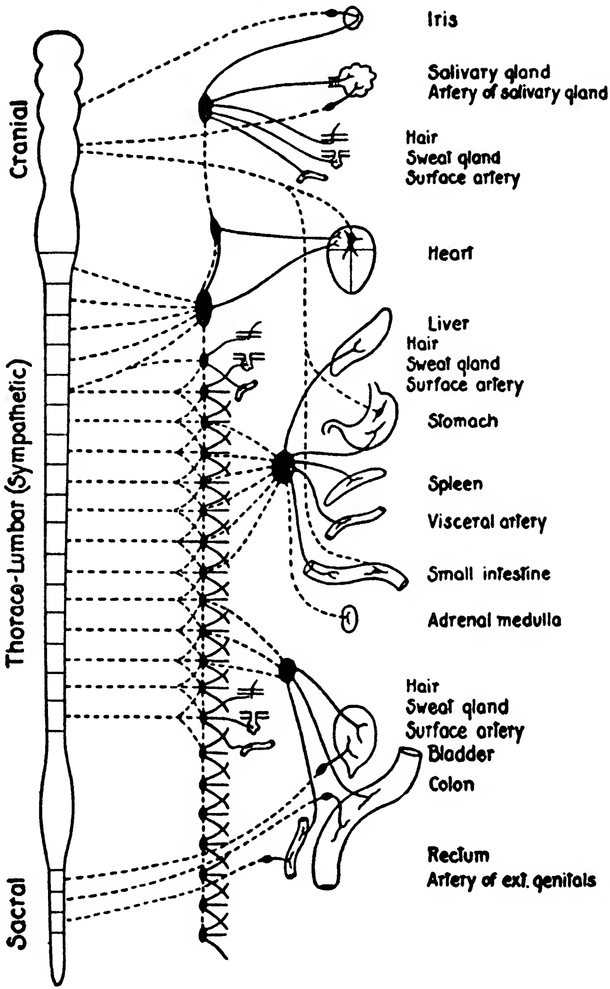


FIG. 46.—THE AUTONOMIC NERVOUS SYSTEM

[After W. B. Cannon; from P. Bard, *Foundations of Experimental Psychology* (Clark University Press, Worcester, 1929)].

with the neuro-muscular apparatus, *i.e.*, the autonomic accessories and the glands, viscera, and blood vessels which they control, should be brought into requisition. If you will examine the preceding figure, (46) you will see that impulses sent out from the spinal cord and the brain stem through the outlets of the autonomic ultimately reach stomach, intestines, tear ducts, heart, lungs, blood vessels, sweat glands, and many other organs and tissues which patently contribute their share to the typical picture of the organism in emotion. Some of the impulses are excitatory and some are inhibitory. It has never been shown that the organism is unable to make a predicament without these factors; but the factors might be expected to contribute to the character and to the coloring of the seizure. Besides being a regulatory device for many bodily functions, the autonomic system of fibers, whose impulses are all supposed to be outward-flowing from the cord and brain, serves to produce diverse effects in many tissues and innervate many structures of the body. The middle (thoraco-lumbar or sympathetic) third of the system appears to act as a whole, innervating in common all those parts of the body which are enumerated near the middle of the figure.

We must not assume that this elaborate accessory to the cord and brain is wholly reserved for emotional seizures. Impulses into the autonomic normally, perhaps constantly in health, affect the functions of stomach, intestine, heart, blood vessel, and many other parts; they are also concerned in glandular secretion and in the production of hormones. The theory which makes these autonomic structures contributors to emotion must rest, then, upon some functional variations on the side of excess, deficiency, or selective exercise and not upon the essential autonomic functions themselves. Moreover, the fact that the behavior of the dog or cat with all sympathetic connections severed retains its disturbed or 'emotive' character would tend to discredit this resource.

There is also other impressive evidence against the theory that the autonomic is the primary resource of emoving. Cannon and others, noting this evidence, have sought the essen-

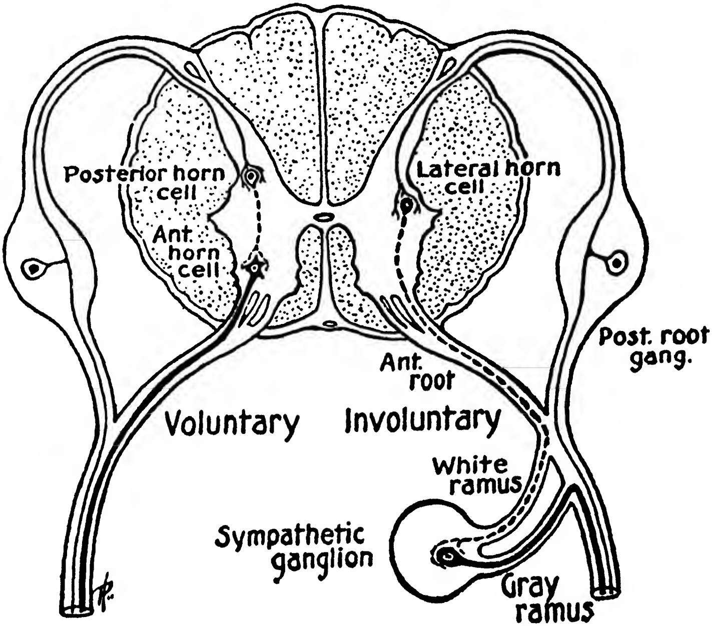


FIG. 47.—A SOMATIC NEURONE LEADING FROM THE SPINAL CORD TO STRIPED MUSCLE (ON THE LEFT) AND AN AUTONOMIC (SYMPATHETIC DIVISION) NEURONE LEADING OUTWARD (ON THE RIGHT) THROUGH AUTONOMIC GANGLIA TO BODILY ORGANS AS SHOWN IN THE PRECEDING FIGURE

[From J. J. R. MacLeod, *Physiology and Biochemistry in Modern Medicine,* (Mosby, St. Louis, 1926)]

tial bodily basis in a subcortical part of the brain called the thalamus. Attention has been called to the thalamus partly from animals with cortex removed which still exhibit alleged

'emotive' behavior, partly from lesions in the thalamus itself which seem to induce certain emotions, and partly again from the strategic position of the thalamus as intermediate between the cerebral cortex above and muscles and receptors below. Cannon notes that nerve impulses excited at the receptor may flow to the thalamus as well as to the cortex. In the thalamus they are given—as he supposes—a certain organization which adds 'a glow and color,' an 'aura of feeling' to the 'sensations' for which the cortical processes are responsible. Although his theory of a thalamic 'seat' of emotion presupposes an emotion which is simply constituted of sensation *plus* feeling, instead of our predicamentive functions, it may be that this enigmatical region of the brain has some specific contribution to make.

We can hardly say that the physiologists have yet given us a satisfactory account of the bodily support to these troublesome operations. While it is clear that muscle (skeletal and smooth), glandular secretion, autonomic system, and brain, are all involved in supporting and maintaining the predicament and the attempts at resolution of it, we are still far from an exact description of the peculiar pattern or patterns of bodily activity which account for these psychological functions as we have described them in this chapter. [66]

The extensive draught made upon the body for the initiation and the conduct of the emotions suggests a complicated and tangled government. Indeed, a psychological function which so easily gets out of hand and which so readily enthralls the organism may seem by its nature to lack governmental control. It is true that the emotively inclined organism is, when the seizure comes, more or less at the mercy of its predicament and of its insoluble problem. But managing the inclination, facing the dramatic situation, keeping an even keel, and working healthily toward a suitable final stage and outcome, are all activities which call for guidance and control.

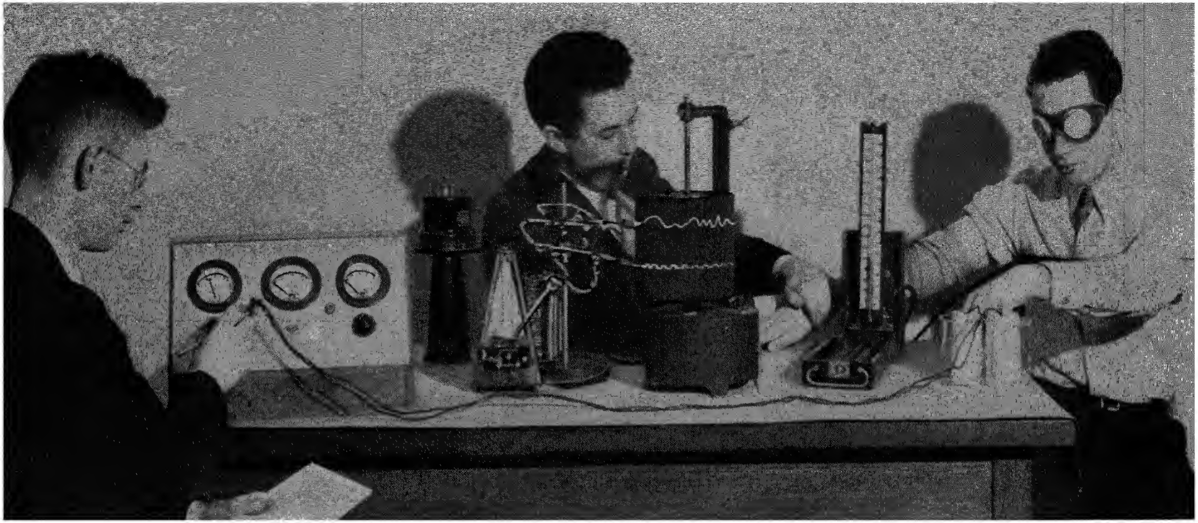


Fig. 48.—Methods Adapted to the Registration, during Emotive Seizure, of Changes in Blood Pressure (Mercury Scale at the Right), in Breathing (Pneumograph Attached to the Subject's Chest and Recording on the Rotating Drum), and in Skin Resistance (the Subject's Left Hand Is Immersed in Liquid Electrodes and the Resistance Is Read Off by the Experimenter at the Left of the Picture

[From G. Murphy, *General Psychology* (Harper and Brothers, New York, 1934)]

As regards the *outside factors* in government, we find the cosmic train of events to be of less moment in emotion than in perceiving and acting. The mere rain of stimuli is less important and so is the sheer passage of events of a physical kind. But the human side of the environment is, on the contrary, of very great importance. The social side of living is constantly presenting situations which easily become 'dramatic.' Getting on with family, friends, associates, and the great public is full of drama. Just what coloring the drama shall take depends upon the emotive inclination and the attunement of the individual. The steady, capable, sane, and healthy individual is best prepared to enter the drama as an active participant and is also best prepared to resist seizure when the situation can be managed in other ways. Many persons manufacture, by the wrong inclination, a dramatic involvement of themselves where a fortified person would deal with his problems more economically by way of effective action, comprehension, or hard thinking. Those who insist upon dramatizing every turn in life are promptly recognized by their fellows as instable sentimentalists.

The first point in government, then, as government touches the human situation, is to emove only when emotion is called for. And the second point is to command the dramatic situation in such a way that it shall take the most appropriate direction. In the emotive train described above, the mother may 'love her baby to death' or may soberly exercise herself in its proper care. The jealous person may nurse his hatred or wrestle successfully with selfish promptings. The grief-stricken may indulge in self-pity or struggle back toward routine. The tempering, therefore, and the general direction of the predicament lie, at least in part, in the hands of the emoved individual. Even joy or relief after long strain may, unless it is directed and controlled, get out of bounds and make either a fool or a nuisance of its boisterous victim.

At this point, a common refuge of men is to avoid the necessities of government by some form of flight or *fugue* from the emotive scene. Men run away, they kill or otherwise dispose of the offending agent, they imbibe alcohol or inject narcotics, they plead illness, they take a vacation, they marry, they lie, and they pretend indifference or callousness. Nowhere is man's ingenuity more resourceful than when dodging the issues of an impending seizure.

About the *organic* means of government we know less, and again we are less able to manage and direct these means of control when the emotion is upon us. A body healthy and vigorous in a generous way is a powerful ally. So far as the sick, the ailing, and the convalescent encounter dramatic situations do they realize the handicap of weakness and disability; and the medicaments of the doctor's case do not always suggest the best therapy for the patient who falls into fretful and desponding emotions. For the well, a régime and mode of living that prepare the body to resist the emotive seizures are prime governors. On the other side, an habitual encouragement of fainting, palpitation, collapse, and self-pity will soon lead to mismanagement and loss of emotional control even in the healthy and sane.

Government from the side of *history* is just now a matter of ardent discussion. The practice of psychoanalysis implies that many emotional seizures, as well as many neurotic symptoms, are either instigated or exaggerated by events in the biographical past of the organism. To bring back the primary dramatic scene, the method encourages the memorial functions by way of 'free association' or other device. The old drama, once brought to light, is discharged by an alleged 'transference' to the 'analyst.' Without debating the claims of this theory, we should all agree that the sting and power of the predicament frequently are lodged in the history of the individual. In so far as the historical government needs revision,

then, it would seem to be sensible to revert to the antecedents of the emotion in order to administer a corrective.

We should encourage an erroneous view were we to imply that emotion is always a hazard to the organism. So often do we dwell upon excess or mismanagement that we easily look upon the whole range of emotive functioning as unwholesome and unhygienic. This view is wrong. Without dramatic situations life would be flat and colorless and the coherent organizations of men impossible. A life without predicaments would be stale and without issue or profit. When properly governed and adequately limited in range and occasion, emotions help to make up the rounded human life of struggle and accomplishment. An organism which found itself promptly adequate to every exigency of the moment and capable of foreseeing its future needs would soon, wanting new occasions, automatize its operations and rest upon its functional facilities. There development would tend to cease. New occasions and new problems themselves, meeting a ready and efficient organism, would fail to stir the complacent individual to difficult endeavors.

Moreover, we must not forget that emotions have their social side, the predicament commonly involving other persons. What society would lose without the mellowing and socializing effects of the emotive seizure, it is difficult to overestimate. "Only restless activity," exclaimed the poet, "makes the man." But activity is not enough. The resistance which free activity meets in the predicamentive check is quite as important in human affairs as are the vigor and enthusiasm of the active and restless life. [67]

CHAPTER VIII

INSPECTING AND COMPREHENDING

The simpler forms of perceptive apprehension and of action have been the fundamental resources of the vertebrates as well as of many of the invertebrate forms. By keeping the run of the most important events in the immediate vicinity of the organism and by following through in action the course which the living body has to take to meet the immediate necessities of life—in feeding, seeking mates, caring for the young, migrating, and avoiding death—, many animal forms, standing at many developmental levels, have added these two kinds of performance to the physiological processes concerned in intake, output, and internal economy, and so have better sustained themselves and their kind on their life-course. Instead of a constant and enduring exercise, we must observe, however, that these fundamental operations of perceiving and acting have, in many of these animals, been merely episodic, appearing as important occasions arose and lapsing as they passed. The complications and crises of living also have brought in, on occasion, passing predicaments of an emotive sort. The continuities and nice interplay of the functions, as we know them in ourselves and in some neighboring forms, we must not extend too far, then, as we proceed downward to simpler and more remote creatures.

But the behavior of man has not entirely depended upon these more primitive and isolated psychological resources. More firmly organized trains of perceptive function, the memorial and imaginational references away from the present,

and the tangles and snarls of communal living have eminently enriched higher mammalian life by more elaborate and continuous activities, not dreamed of by the fish, the turtle, and the opossum. One of the first advances beyond the more primitive levels has added *inspection* to the animal's repertory, a function which we shall now consider.

INSPECTION

To understand just what novel turn of function appeared with this new resource, we must return for a moment to perception; for inspection is an extension and modification of perceiving, just as we found the most primitive form of imagining to be. There the extension looked toward the immediate future, contriving the not-yet-but-about-to-come. Here—in inspecting—the extension tends toward a completer grasp of the object or event. To in-spect is literally to-look-within-and-derive-significance. I apprehend the ivy vine here at the edge of my window, but I inspect its gradual threat to my working light. I apprehend the old Hopi rug hanging on my study-wall, but I inspect the plan of its clever weaver. I apprehend the objects on my desk, but I inspect the need for sharpening my stock of pencils. I apprehend the insect crawling across the floor, but I inspect the crawler and discover that it has eight legs. I apprehend the horse-race, but I find on scrutinizing inspection that my favorite has cast a shoe and is likely to come out last. I apprehend the puffing freight train on the hill, but inspection informs me that ice on the rails is slowing it down. Always in inspecting a drilling-in which enriches the products of mere apprehension.

To make sure that inspecting does not extend the perceptive form of apprehension alone, we must note that it also relates to remembering and imagining. When I remembered, in another context, that I had left open my windows on a

gusty morning, I decided upon inspection that the present shower would have swept in and dampened my carpet. As I now recall the quizzical smile of my table-partner, inspection tells me that she was amused at my naïve remark. The anticipated woodland which I was told I might look for upon the road about one o'clock is enriched by the inspecting comment that I should find there shade for my luncheon and siesta. The mechanical figure which arises as an imaginational accompaniment to my reading about a clever apparatus receives new significance as I discover on inspectively considering it that it applies a new principle to an old problem. And the fictional statue which the sculptor imagines as he approaches his studio for work becomes, by an added inspection, symbolic of courage or of hope.

We should see, then, that all the forms of apprehension may be supplemented by the new functional gift of inspection, and that all the products which we have come to know as typical issues of perceiving, remembering, and imagining may receive new contents and new significance by the same means.

It is not always easy to decide just where apprehending leaves off and inspecting begins; just as it was not always a simple task to decide just when the simpler imaginings ceased to be a mere perceptive extension of presentness. Again we note the intermediate shadings of closely related performances. That is not disturbing; for only arbitrary distinctions are able to draw hard and fast lines, while we constantly find in nature continuities and transitional forms. History is full of half-stages between adjoining epochs, and similar biological species often stand related through puzzling intermediates. Even the elemental forms of matter, which were once regarded as standing in a discrete and immutable array, have in certain instances suffered a transformation one into another, which suggests a common constitution and a common plan of organiza-

tion. The physiologist might tell you, too, that digesting, the transportation of materials, aëration, and cellular deposit were not the distinct and separate bodily functions which they appear to the elementary student.

It appears, therefore, that the describably unlike, but closely related, functions which we find in our psychologies stand to each other very much as do other partly discrete and closely related functions and structures to be found elsewhere in the world. As for the distinctive nature and *quale* of inspection, we have only to regard such typical and unequivocal instances as the inspection of a switching mechanism in the railway yards and the inspection of a blighted peach withering on the tree to convince ourselves that we have here a real psychological variety.

We may say in general terms that inspecting is an examination or scrutiny. In its visual form, it is plain to see that it is a 'looking for' or a 'looking into' and not a simple 'looking.' And if we use 'looking for' in a wider and figurative sense, we may agree that it generally applies whatever the senses used and whatever the form of the preceding or accompanying apprehension. The inspection of the fire-whistle in order to place the fire, the inspection of the vague ache in the back to discover just where and why it is, the inspection of the rhythmic music to discover the place of the accent, and the inspection of the new confection in the mouth to determine its precise taste are all facts of the same order and all representative of one and the same function.

While we have related inspecting to apprehending we must go on to note that this new mode of performance is also bound up in an intimate way with acting and emoving, our executive functions. In taking apart a block-puzzle with the intent to discover how it is constructed, we clearly inspect as we act. With the removal of each piece the action-determination is modified by the scrutiny of the whole and of its parts.

While acting is often instigated and set in its course by perceiving, it may just as well be determined by a quizzical and inquiring manipulation. The infant's half-clumsy handling of the toy in its hands goes on with this sort of noting and scrutinizing care, and our own maturer and more practiced actions frequently receive their significant guidance toward a correct issue under the control of this same function. As practice increases, however, and skill grows, the eliminations and foreshortenings which we have already dwelt upon (Chapter v) come with the dropping out of inspection. Instead of examining and 'looking into' the knitting, the typing, or the position of the hands on the bat or the racket, we merely and fleetingly perceive—we no longer inspect.

With this reference to action, you will yourself be able to think through the conjunctions of inspecting with the emotive performances. Very often the dramatic character of the situation is not revealed by apprehension alone; it commonly requires scrutiny. That reminds us of the earlier statement about the emotional situation tending to be symbolical. The ambulance siren screaming down the street implies an accident and thus awakens dread or fear; inspection of the threatening cloud suggests impending wind or lightning and hence terror; the actions of the loved object are scrutinized for suspicious interpretations and thus arises jealousy or hatred. There is no doubt that one of the chief reasons for the greater range and complication of the human emotions, as compared with the predicaments of other animals, lies just in the human development of that sort of inspection which sees beneath the surface and interprets in this symbolical and highly significant way.

How Does Inspection Arise?

In all of our functional descriptions we have found it important to understand how a given performance arose, what

instigated and initiated it, and how it was carried on. Let us now ask that question of inspecting.

In the first place, the many instances given will make it appear that inspecting proceeds from a *task* and that the task is commonly set by some form of *instruction*. Such instances as the crawling insect and the ambulance siren illustrate the *occasional* instruction, the occasion falling upon the organism and leading it to inspect. When my secretary remarks, "I must check the galley proofs," she begins an inspection from a *self*-instruction; while my suggestion that she look through the files for a certain letter initiates a like function by way of an instruction which falls under the *formal* rubric. Taken all together these three sources of instruction account for a very great number of the inspectings which serve to acquaint us with the import and bearing of the day's affairs.

Another aspect of these functional origins is the priming of the organism itself. An etching does not lead to inspection in the dog, though a strange and savorous food might, but the command of the hunter (formal instruction) induces the setter to nose the grass for a hidden bird.

To inspect usually implies that the individual, whether man or brute, has sufficient apprehensive acquaintance with the object or scene to make the inspecting a real task. Some of the most striking instances of inspecting derive from a general priming which serves a whole host of occasions. Thus the philatelist inspects without specific prompting every unusual stamp which comes his way. The taxonomist is primed for plants, the junk-dealer for metals, the printer for types and styles, and the carefully dressed woman for clothes. This generalized priming is a result of long concern with a class of objects. It is one of the major elements in psychological development, for it leads to assorted, critical, and systematic knowledge, as well as providing a prompt readiness in assimilating the new to the old. When we come to consider matters

of development for their own sake, we shall then see that it is an issue of learning in the sense of our previous discussions of that fertile subject. The fact of priming is obviously to be set down as a fundamental form of government serving as a selective initiator and guide to the inspective functions. The bodily means here employed we easily call 'neural trends,' not yet being informed by the physiologist what the chemical, physical, and physiological residues of long and repeated exercise of the nervous system are.

Inspection and Insight

It has been shown that many cases of alleged 'insight' among men, apes, monkeys, dogs, and some other animals are just plain inspectings, integrated either with perception or with action. The ape that telescopes one stick into another to secure a remote food morsel beyond the cage does more than apprehend one by one the sticks and other details. Indeed he does more than apprehend them all together. By inspecting the field, he makes the whole thing an appropriate occasion for acting. Behind the determination of the action, then, lies the inspecting of a situation which becomes an integral part of the action in its second stage (p. 211 above). Human puzzle-solving usually involves inspecting in much the same way, save that here the issues of this function more readily appear in verbal remark and comment than in the determination which leads to action. The resulting movements (as in manipulating the mechanical parts or in writing in the trial letters of the crossword puzzle) are more or less incidental to a new perception and inspection. Although we speak of animal contrivances as 'puzzle-boxes' and 'mazes,' it is clear from the animal experiments that inspecting commonly plays a smaller part here, and running about at the behest of the confining occasion a greater part. The general outcome is much the same, being effected under the remodeling effects

of learning but making, as a rule, less use of true inspecting. In all these cases, it would be better not to use the mystical term 'insight,' at least not until some plain account of this alleged operation has been given.

The inspective function is readily introduced into the experimental laboratory for exact study. As experimenter I may collect a score of small objects, set them one by one behind a screen, and arrange to expose each to you, the observer, by opening a window in the screen for, say, $\frac{1}{10}$ second. Before each exposure I warn you with a 'ready' and then cause the window to open and close again. Just before the exposure I say (formal instruction) "Is it valuable?" Then appears a brilliant cut stone. Another object may be an opaque figure with the query "How heavy is it?" These inspectings with questions usually lead to comments by the observer (*e.g.*, "it looks like a diamond," "it is worthless," "it may weigh an ounce," and the like). The observer reports both his comments and the course of the inspecting.

Other experiments call for distinguishing, comparing as to size, naming, and so on. All afford a favorable opportunity for distinguishing functions which lie near the border line of apprehension and inspection. Where the task set implies hesitation and doubt, a 'looking for' is the common resource added to plain perceiving; but where the task is solved straightway upon exposure and the comment immediately falls out "yes," "light," etc., perceptive apprehension frequently suffices.

These experiments serve at least two other ends. The one is the discovery of the limit of discrimination, the noting of differences (as of colors, tones, or shapes), and the other is the process of foreshortening under repetition. The observer may begin with an elaborate inspective inquiry into the object presented and end (after 50 or 100 repetitions) with a mere thread of perceptive activity which leads quite automatically to the report "right heavier" or "first tone lower."

Inspection and Comment

Reference to 'comment' with inspection suggests that language may be intimately involved in this function. It is. The verbal comment may be so closely bound up with inspecting that we speak naturally of an 'inspection-and-comment.' Not only do words report the outcome of the scrutiny. The fact that we have at hand such words as 'longer,' 'heavier,' 'lower,' 'diamond,' 'cheap,' and 'metallic' aids the scrutinizing examination itself. Where words are lacking, as with the dog undergoing 'conditioning' with sounds and electric shocks, a movement or lack of movement has to be built up to exhibit the fact that one stimulus acts differently from another upon this creature. Whether such a conditioning builds up a scrutinizing distinction in the dog—or so much as a *perceived* difference—is not known. But we, with our verbal labels and qualifying adjectives, readily take up the task of inspectively boring into the object to discern its nature and its relations to other objects. Perceiving itself gives occasion for designating by names and for finding descriptive epithets which denote events; but inspecting leads to more precise distinctions, to a fuller and richer description, and to more adjectival and adverbial qualifications.

COMPREHENSION

Just beyond inspecting comes comprehending. Here is the same gradual transition from function to neighboring function as we have seen before. In this case, comprehending doubtless came later, was more difficult, and led to richer and more elaborate products than inspecting. While inspection digs into the hidden significance of the object or event, comprehension *constructs or enriches subjects or topics* which the object illustrates or exemplifies. Another (but more ambigu-

ous) word for comprehending is 'understanding.' We say that we understand boxing, farming, or the making of typewriters; we understand meteorology, physics, or soil-chemistry; we understand how the internal-combustion engine works and why beads of water form on the sides of the ice-pitcher; we understand the page we are reading and the points hammered home by the vehement street orator. It is obvious that the term covers a wide area of human abilities and performances. In fact the word 'understanding' is too inclusive and also too ambiguous to be quite useful in psychology. So we use the less hackneyed and more precise word 'comprehension'; and to make sure that we are really discussing a concrete kind of operation—an active mode of functioning—we shall prefer the more transitive form 'comprehending.'

What do we actually do when we comprehend? Let us begin again with concrete instances. I pronounce the word 'hunger.' To you that signifies something, something which is more than your state before a delayed dinner. The delayed dinner suggests only a case or instance of hunger. It is not the hunger topic, which is not an object and not the state of any given organism, but a subject about which various things may be said and which may be illustrated by an indefinitely great number of instances. Could we collect all the cases of hunger (or of fright or of weather or of prices or of disease) we still should not have in the sum-total what we mean when we say 'hunger' (or 'fright,' or any of the other subjects). What we mean and seem to comprehend when we dwell upon the hunger-topic covers all individual hungers but is not identical with any. It is, in this sense, something more abstract and general than any case of hunger, yet in its significance it is utterly definite and unequivocal.

It is now obvious that the function of comprehending is a device which carries the organism beyond the particular, whether the particular is present, past, future or fictional.

It derives a product which is independent of any particular place or particular time. It is a kind of significance but not such a specific significance as commenting affords, for the comment refers to a thing or occurrence; to the perceived siren or freight train, the remembered open window, or the imagined woodland. It also relates to what I am doing or to the emotive significance of the blood on the sidewalk or of the kidnaper's note. However deeply we dig into the thing as we inspect it, it is still the apprehended thing, or the actional or emotive thing. But when we consider hunger, the weather, municipal control of business, or any other such subject or topic, we have passed beyond the particular and the individual. Let us see how the adult human organism does this very important piece of work, which has accomplished wonders in making knowledge and in making man's life a human life. [68]

How Do We Comprehend?

It would be difficult to comprehend, *i.e.,* to think about matters in a topical way, if no one else had ever comprehended before or could place the fruits of his comprehending at one's disposal. It is a limitation of other animals. They cannot pass topics around. Often they have calls, roars, and grunts which give to others an inspective kind of significance for the individual occasion (the monkey's chatter at sight of an enemy, the bird's mating call, the trumpeting of the disturbed elephant, and the like); but little or no provision for dispensing topics through the medium of language or otherwise. The human child, on the contrary, lives in a shower of topical words and phrases which it rapidly comes to use topically, *i.e.,* to comprehend when he hears certain vocal sounds and sees such topical gestures as the speaker uses to emphasize his intent. We comprehend, then, in a comprehending atmosphere which is filled with the topical products

of others as well as of one's own earlier comprehendings. [69]

This presence of topics in the environment has to be considered in answering our question because the commonest case of the exercise of this function begins with these earlier products. This commonest case will be the first of three which we shall distinguish as A, B and C.

(A) As we have seen emotion begin with the dramatic situation, action with the doing-task, and inspection with some appropriate form of instruction, so comprehension may begin. Suppose I say to you 'history,' without any specific instructions. The chances favor your taking 'history' as a topic. You might reply 'yes; I understand.' So far we have a bare topic, which is the sheer significance of the word. That is the simplest and briefest form of comprehending. The sound (which is commonly not perceived as a sound at all) is the immediate occasion for your comprehension. We might say that the sound is a verbal symbol, and that it symbolizes the topic 'history.' So far as the brief and curtailed psychological functioning is concerned, it is similar to the automatized action when we promptly ward off a blow and to the perceptive flash when a picture is presented for a tenth of a second in the exposure-screen. All of these cases imply an organic readiness which suggests many like occasions in the past during which inclusion, ligation, and the other modifying factors have been operative.

(B) The word may, however, lead to a more elaborate process of comprehending. Starting with the word you may go on to collect items which are 'historical'; a senior course in English history, Gibbon's *Decline and Fall,* early man, the great historians, the past, and so on. In this way you will fill out and so *realize* the topic. The bare topic is clothed. It serves as a common center from which the comprehending function sets out in various directions. This may be all. 'History' was at first a perfectly definite topic, and the subsequent

operations have simply commented upon and illustrated the topic and so given you a realization of its fuller significance.

We commonly remark that we 'know' words or topics quite well before we attempt to define, illustrate, or otherwise realize our knowledge. Most that an individual knows at a given time is known only in this implicit topical implication which serves notice that a subject or a class of individuals is familiar and could be expanded if time or occasion permitted. This is one of the great services to man of verbal symbols and of grammatical constructions. Words are counters and may be used in the 'bare topic' form without amplifying them by more comprehensive descriptions. Also they may be passed from organism to organism because they are thus held in common by all men in a given culture. The same is true of phrases and sentences. I remark that 'history is interesting,' and you assent or deny without the process of realization. But if argument ensues, this process is certain to follow. Where we find that, as a general rule, another has a comprehension of topics radically unlike ours, we remark drily that he speaks 'another language.'

(C) There is a third case, in which comprehension goes still further. Let us assume a subject practically unknown; *e.g.*, hydrography. Unless you have made a systematic study of seas, lakes, and other bodies of water, you will find hydrography to be little more than a word-like sound. Compare, for example, 'hydrography' and 'geography.' The second will be a real topic; the first may not be. A still more striking case is presented by an unknown foreign word. Take the German *Vorstellung* and its English equivalent 'idea.' Now when the topicless words are heard or read they may initiate the processes of comprehension. If you will look for definitions of 'hydrography' in the dictionaries, consult students of land and sea, take courses in a department of geology, and so on,

you will build up the hydrographical topic. There you do more than realize the topic; you *initiate or construct* it. This is the process that the novice in algebra goes through in his introductory course. Any difficult subject approached for the first time is—at least in spots—topicless. Gradually relevant items are collected—often in a flash. Then the student exclaims: "Ah, now I understand!" Such occasions may have come to you in reading this very book. The present paragraphs, *e.g.*, are an attempt to serve you in just this way, to help you to initiate and definitely to grasp the psychological topic 'comprehension.' A more diverting instance is the sudden illumination which flashes out finally from a motion-picture which was well under way when you entered the theater. To illustrate a long term of preparation, you will do well to compare the ending of a picture seen straight through with the same ending after you have been in the theater for only a quarter-hour. The actual scenes are the same, but the topical comprehension is far greater after the complete view of the play from its very beginning.

These three cases of comprehending may be set down as follows, beginning with the least expanded and following in the above order.

(A)	Symbolic Comprehension				
(B)	Symbolic Comprehension	>	Adding relevant items	>	Enriched topic
(C)	Symbolic Intimation	>	Adding relevant items	>	New topic

While it is the rule with sophisticated human adults to begin with a topical nucleus ready at hand, these clever creatures have devised various substitutes and surrogates. Almost

any sort of occasion may lead an organism which is primed with curiosity. When I saw the crawling object a few pages back, a priming for classification in entomology might well have led me to exclaim "What is that, then, if it is not a (six-legged) insect? Where *does* it belong?" Here my entomological priming would have led me to bring the observed creature under the topic of phyla and classes. What men call 'the trained observer' is an individual primed in this way. He perceives and inspects, but he also sets the case in hand under the appropriate topic of his science or profession. The individual who habitually and discreetly looks for the general topic underlying and explaining the individual case is an understanding or 'intelligent' individual—though you will look in vain for this operation in most writings on the 'tests of intelligence.' [70]

The Relation of Inspecting and Comprehending to Learning

It will hardly be necessary to dwell upon the fact that a general definition of learning would include these two functions as well as those of apprehension, action and emotion. The immediate product of inspecting is the analyzed and enriched object; the immediate product of comprehending is the vague or precise topic. That means that each exercise of these functions adds to knowledge and adds to the practiced command of the organism's facility with new intellectual problems. The teacher's constant caution, "Do not be content with rote learning; assimilate and understand what you read and observe," is just an admonition to exercise the two functions of our present chapter. Emphasis upon the routine behavior typical of the white rat in the maze and upon the strengthening of associative bonds by pedagogical drill has obscured the psychological and the educational importance of deriving through inspection and comprehension the inner sig-

nificance of things and of topics. Nothing is more important in the conduct of life than the natural exercise and the government of these two 'intellective' functions. [71]

Language and Comprehension

One primary function of language is the transfer of topics from individual to individual. Objects can be visited, inspected and used; actions must be developed by each individual from his own determinations; and emotions are, in a sense, private predicaments which are privately suffered and despatched. But the topic is something current. It belongs to a group of individuals living under common conditions. Language is its vehicle, its medium of exchange and communication. We speak the literal psychological truth, then, when we say that we comprehend what is said to us and what we read from the page. The word, the phrase, or the sentence touches off a topic which is further rounded out in the conversation, the lecture, or the essay.

This suitability of language for comprehension is displayed in its structure. The sentence is the smallest formal unit for the communication of a topic. 'The Emporium announces a special sale,' 'The government has advertised its navy,' 'How each of the cities, New York, Chicago and Boston, loves its own provincialism!' 'The study of philosophy sometimes engenders conceit in the young,' 'How is law related to morals?' 'If nations remain selfish, we may expect war to continue,' *etc.* When occasion requires, the formal sentence is condensed into an exclamation (fire! look out! help!) or into a title (*The Decline and Fall of the Roman Empire, The Last of the Mohicans, Today's Markets, Anthony Adverse*); but it is still, so far as the topic is concerned, a sentence.

In written composition, larger topical units are formed by the paragraph, the section, and the chapter. Then each sentence plays a subordinate part in developing, elucidating, and

qualifying the topic. The clever speaker likewise groups his sentences, announcing his several topics, setting them off by pauses, by emphasis, by inflection, and by shift of position. The art of expository and informative address consists in the simple and clear communication of topics in their appropriate order. It wants the dramatic appeal to the emotions to be found in the play; for its appeal is rather to the comprehensive functions. It also differs from the rhetorical arts, which, as Aristotle has shown, are designed to persuade and to yield conviction, belief, and action.

So firmly have we connected verbal signs with the subject signified that we often regard words, when spoken or read, as themselves containing their topics. As a matter of fact, of course, they are—so far as the organism is concerned—first physical energies appealing to the ear and the eye; then they are simply physiological processes which support the comprehending. The topic is the end and outcome of the function. It is every time produced; not, as we loosely say, directly communicated from mind to mind.

The production of topical significance through reading is a complicated matter, more complicated than the listening to speech, where sounds are immediately incorporated into topics.

Reading has been made the subject of many experimental studies, which have been especially addressed to rate and accuracy. The records of eye-movement, as the gaze follows the line across the page, have made it evident that the creation of significance depends upon a selective process. The eye jerks along, fixating here and there a group of letters, the others being either caught in indirect vision or not at all. The topical meaning is produced out of a complex of clear and obscure visual configurations, rapidly shifting and of short duration. In the 'eye-reader' the topical and inspective significances may follow upon these visual patterns and the

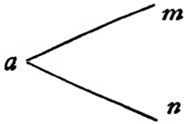
accompanying neural and motor changes. In the 'ear-reader' or 'throat-reader' sounds or vocal contractions are first produced and only then does the significance appear. Apart from a host of outside conditions (type-face, illumination, leading, length of line, and what not) comprehension depends upon the readiness with which whole constellations of central neural trends are made actual: depends—so far as the central nervous system is concerned—upon what we may vaguely call a *functional readiness.* What the want of this readiness means we realize when we open a book in a language only slightly known to us. So far as our resources are concerned, comprehension is obviously much more economical than the apprehensive functions; for it is the rule (especially in reading and listening) that elaborate and complicated topics are carried by slender threads and by simple integrations, patterned and unpatterned.

Comprehension and Acquisition

Comprehension is a kind of acquisition in the sense that —as we have seen—we may form new topics (*e.g.,* new knowledge of the chromosomes or a first acquaintance with the geological periods), or we may enrich or modify old topics —a much commoner form. Sometimes the materials are supplied in perception, as when we examine a cream separator to comprehend the principle of its operation. A great deal of our classificatory knowledge comes in this way; topical formations out of materials which are mainly perceptual. But the largest part of our comprehension rests upon, and makes use of, supporting topical trains. For example, I hear the word *sunset.* This first supplies a bare topic. As I further consider it, the topic is enriched by such completions as 'the view last night from the hill,' 'that picture of Turner's,' 'those evenings in Naples,' 'that occurrence at the close of a clear day,' 'the end of work,' and so on. Never do we realize so

keenly the operations of understanding as when acquaintances discuss in our hearing topics (*e.g.*, foreign exchange, the British Cabinet, the composition of brass) for which we possess only meager resources.

Experiments have shown in a striking way the possibilities of a mutual interference among such multiple completions. Müller and Pilzecker prepared pairs of nonsense syllables after the pattern where *a* is followed as often by *n* as by *m*.



Later, when *a* was presented by itself, with the instruction to give a syllable which went with it, the observer's attempt frequently failed because *n* inhibited *m*, and *m* checked *n*. Here *a* was a bare nonsense syllable, such as *juk* or *zer*, and it did not lead on to other syllables because there were only two leads and these were of equal strength. This blocking is known as *reproductive inhibition*. Ordinarily we do not suffer from it because our topics have many outlets of unequal strength and we take them in order, thus gradually extending our knowledge about the subject in hand. We do, however, complain at times that our heads are empty, and that we cannot comprehend even a simple exposition. And now and then, when we are shown a word and instructed to answer with any other word which comes, we do sit helplessly and gape just because two topical leads are equally strong and equally immediate and so neither proceeds to its goal. Thus 'vinegar' resulted in a blocking for me because 'jug' and 'acid' checked each other.

Interesting topics are those in which the representative word will have one meaning or another according to circumstances. Thus *man* may mean the human species or the male sex, *labor*

either work or a party opposed to capitalism, *suit* either clothes or a legal process. According as we are primed in one way or another do we proceed with things relevant to the one topic or the other.

We all know occasions where the topic refuses for some time to appear. The partially deaf entering where many speak are familiar with this discomfort, and so are we all when the radio fades and sputters, releasing only fragments of speech or music. Upon a tardy entrance to a lecture, one listens until the topic suddenly emerges. And in starting a serious book, whole chapters may be read in a haze until, at a given page, the meaning of the whole flashes out. The method of scientific discovery sometimes assumes the same course. Some alleged cases of 'insight' belong here rather than under inspection. These are instances where a flash of comprehension comes suddenly after poring or puzzling over a problem. Here the flash is prepared for, first, by a general task looking toward discovery ('What is this puzzle picture to be when I get it?' 'What is this author driving at?') and, secondly, by the accumulation of material under the task. [72]

Bodily Support and Government of Inspecting and Comprehending

The close relation of inspecting to apprehension and to action suggests that all the resources there brought into play are also useful in inspecting. But we may well ask, "What is *specifically* required, on the bodily side, for inspecting?" Ask but not readily answer! Surely nothing so gross as a new brain-center or a new neuronal tract! Since the essence of scrutinizing consists in dwelling upon the object and asking for further information about it, we may expect to find—when we know more about sustained processes in nerve, muscle and brain—that *any sort of bodily integration which tends to maintain a function in course* will increase its product

on the side of added significance. Here doubtless muscular tensions and whatever lies behind them play a great part. A similar demand is laid upon the body in maintaining the determination which carries the action on toward its goal. It may be that sustained muscular tonus and the central devices which maintain it are essential factors in both cases. Another factor is the task set under instruction. The digging-in implied in inspection requires that the occasion, the self-object, and the verbal (formal) incitement from other individuals, all instruct the organism to seek further information about the object, scene, or event under scrutiny. Whatever searching mechanisms there are in the body (muscular, visceral, autonomic) are, or may be, turned to account here to manufacture the products of inspecting. What these devices are we know very imperfectly. But we do know that many organisms capable of perceptive apprehension are narrowly limited in their inspective range. We infer, therefore, that the body must add, in inspection, some agency not necessarily employed in perception.

As for comprehension, the essential mechanism would seem to be that which provides for the derivation of the 'bare topic' (Case *A*) from a sound or sight object (the verbal sign). A certain sound uttered (*e.g.*, 'labor') turns out, by way of product, that which is characteristically at odds with 'capital' or that which is characteristically contrasted with 'play.' That is the 'labor' topic. The history of the function is probably just another case of inclusion, substitution, and the other changes which, taken together, are learning (cf. Chapter v); but what goes on in the body (probably in the cerebral cortex chiefly) no one knows. If we knew this fundamental device, we should probably be able to proceed with the collection of the items (Case *B*) and with the sheer production of the topic from non-topical materials (Case *C*).

As for government, it is clear that the organic forms of

control (Chapter i) are primary both in inspection and in comprehension. Here the body is relatively free from environmental guidance, save that certain objects seem to have a special impressiveness and so manage to get themselves inspected to the disregard of other objects and save that topics are everywhere at hand in human speech and writing and so manage to give the individual organism a start upon its own tasks of comprehension. Society, so to say, makes a gift to the organism of its topical products. The historical forms of government appear in biographical residues, the individual comprehending according to its own past, and exemplifying (more than in most other functions) the necessity of long and careful training. To understand upon a given occasion generally means that the individual has gradually provided himself both with a stock of bare topics, for which language is the main tool, and with the habituated facility for clothing these bare topics and their surrogates with instances and occasions (Cases *B* and *C*) which lead to an enrichment of the primary materials. Both in inspecting and in comprehending the best practical government rests upon the 'stores of knowledge' and the facility with which the individual sets himself scrutinizing and comprehending tasks. There can be no doubt that this double preparation is essential to the pursuits of 'the intellect.'

In the next chapter we shall see how this preparation serves also to govern the processes and the issues of hard thinking or elaboration.

CHAPTER IX

ELABORATIVE THINKING

The Nature of Thinking

It has long been held that thinking or reasoning is a universal mark of human beings, a mark which nobly distinguishes man from the unreasoning brutes. This belief cannot easily be sustained; for, as Wundt once remarked, man really thinks very seldom and very little; and, on the other side, the recent intimation that some of the non-human animals are capable of using certain limited forms of thinking makes the broad distinction still more dubious. At the same time, the high repute of thinking among human beings suggests that this psychological resource presents to us a problem of very great importance.

What is this thinking which has long impressed man as a peculiar and notable possession; which is said to have revolutionized his life and to have enabled him to control nature? Is it a mental process, a 'tonguey' form of behavior (as the word 'language' suggests), a form of psychical force, or some inscrutable human faculty?

If we are to seek an answer to these questions upon the nature of thinking, we must leave the region of vague speculation and regard the subject as concretely and as directly as we can. Then we shall easily assure ourselves that thinking is, as perceiving, remembering, acting, and comprehending are, something which is performed or accomplished by the organism. In thinking we solve a certain kind of problem in

a certain manner; and, by its means, we produce a new bit of knowledge, a belief or opinion, a new doubt, or a new way of regarding nature. The members of the budget committee think out a plan of equable distribution of the city's income; the housewife thinks out a way of reducing her kitchen fuel as the cost of coal advances; the pursued bank-robber casts about to devise by thinking a means of escape; the scrupulous voter seeks by thought to 'make up his mind' upon the merits of a political issue, and the scholar determines by like means a new way of attacking a problem in anthropology or history.

In each of these instances the man or woman *thinks out or elaborates* a problem toward an acceptable conclusion. In the 'thinking out' lies the whole secret of this psychological function. The problem has to be formulated in a certain way and worked through in a certain way, using certain special materials and aids. Merely to entertain problems and to advance toward their solution does not guarantee thinking of an elaborative kind. An inspective searching and finding under a definite task may solve a problem and so also may comprehending or acting.

In emotion itself there is a very vivid problem, as our exposition of the predicament has convinced you; and while only luck and time may lead to a solution there, the hope of relief from the embarrassment of the dramatic situation does prompt the organism to attempt all manner of devices for removing the predicamentive problem. Were it only failure to solve satisfactorily that prevents emotion from coming under the head of thinking, we should have to reflect that we do not, by any means, always come out with adequate solutions even when we really and elaboratively think. The alarming persistence of great human problems—for example, poverty, peace, and security—, which would seem to be amenable to competent thinking and never-

theless remain unsolved through generations and centuries, warns us that blocking and failure occur in thinking as well as in emotion. As a matter of fact, we shall discover a closer resemblance between these two types of function than appears on the surface.

Let us see what distinguishes the thought-problem from others and what difficulties the psychologist encounters in describing the elaborative functions.

The psychology of thinking is difficult, difficult of approach by scientific methods of study and difficult also of exposition. Although it long ago attracted the attention of the philosopher and the logician, no means for the empirical study of it were for a long time discovered. The approach in the laboratory was made only when experiment had been successfully applied to the problems of perception, memory, habituation, and action. Then simple instances of alleged thinking were taken, given as problems to trained observers, and the outcome noted. Two surprising results were soon obtained.

First, the observers confessed that usually they found nothing that could fairly be called thinking. It was as if a fisherman should cast his line into a well. There was apparently nothing to catch. These observers were asked to judge which of two tones was higher or louder, which of two lines longer, which of two lights brighter; and they found either that the decision immediately appeared in the form of a word (as 'the second,' or 'that one') or that they sat in suspense until the designation came. Nothing appeared that could be dignified by the name of 'thought.'

We see now—as those men who believed that they had discovered a real experimental approach to the problems of thinking did not see—that the functions concerned in their simple exercises were chiefly inspecting and comprehending, without a shred of real thinking. You have recently gone over instances of the same kind in the chapter devoted to

those more elementary functions. The confusion came partly from the erroneous belief that what is in logic called 'judgment' (*e.g.*, 'This is lighter than that,' 'The first tone is higher') belongs to the psychological processes of real thinking.

The second result was that certain observers who took more complicated tasks—such as the classification of a given object—found materials which they could neither classify nor describe. There were sudden flashes; 'now I have it,' 'this is working out well,' 'how shall I proceed?' 'how difficult this is!' and other sudden intimations. These sudden turns and tricks, which resisted analysis, were called *Bewusstseinslagen,* a German word which may be translated as 'flashing intimations' or simply 'flashes.' Psychologists soon began to say that these were, as they believed, the true thought-processes or thought-elements.

Again we may remark on reflection that these sudden flashes were not either of the essence of elaborative thinking. They have, however, since been discovered to be important devices used by the organism to advance the thought-task toward its solution and so we shall presently have to consider them in our functional descriptions. Here we shall first be concerned, however, with such general questions as the nature of the elaborative type of function, its initiation, stages, and conclusion, its bodily resources, and the means of its government and control. The 'flash' will return in its proper setting. [73]

The Intimate Relation of Thinking to the Other Functions

Let us make it apparent, first of all, that the elaborative functions are not disjoined from perceiving, acting, inspecting, comprehending, and the others, which we have already studied. The functions are hierarchical; some of them basal

and others of them incorporating the simpler and earlier in their more inclusive scope (pp. 15-22). The common opinion—possibly derived from the tendency to close the eyes and ears and to sit passive when we reflect—that thinking is divorced from other operations is wholly erroneous. On the contrary, it uses the others, but in a new and characteristic way. Let us see how.

We begin with some simple tasks, tasks which do not require thinking and which are carried out in apprehension, action, and comprehension, and then proceed from them to thinking.

Suppose that I have been marketing. I consider whether the banknote just now handed to me in making change is genuine or counterfeit; whether I can carry all my parcels; whether I can recall the order of my errands in the stores and so recover my lost umbrella. Here are three tasks awaiting solution. The money I scrutinize as regards coloring and engraving, comparing it with another bill in my pocket. The parcels I run over with my eye, consolidate, fit into my arm, and cram into my pockets. The path to the various stores I retrace in retrospect, verifying my purchases in hand. The tasks once formulated thus involve, as we conceive them, perception, inspection, action, and memory.

What is added when I really think? When, for example, I am asked whether financial embarrassments or domestic cares are the more frequent causes of marital divorcements? The problem itself calls for symbols, and so does its solution. That is to say, both call for a kind of shorthand in which objects or words signify something beyond their own sight or sound. The shorthand may be verbal symbols; or it may be—as at the present moment it is—a vague imaged object whose symbolic reference is a court-room, together with another thin and scanty object which stands for a worried man of business, and a mixed somaesthetic and auditory cackling which sig-

nifies domestic infelicity. 'Business trouble' and 'infelicity' are somehow set against each other by a right-left balance of tendinous strain.

So far the comprehended task; a 'divorcement' topic, the first prerequisite to the thought-problem. Now I know, in this symbolic way, what I want to discover and to decide upon. I wait at first, as for a foreordained conviction. It is at this point that thinking often breaks down. We tend to avoid real elaboration, hard thinking, by an opinion ready-formed or by a prejudice or pre-judgment. The symbolized cacophonous jangle seems somehow more compelling; so I am tempted to say, 'Oh, domestic cares lead naturally to friction, of course!' But this is not to think, so I begin again. Immediately appears a visually presented scene which symbolizes 'myself reading from the daily papers,' and then the words 'usually outside persons are involved,' with the conviction 'but this is not in the problem'...'domestic cares *versus* business embarrassment.' Once more I begin with a restatement. The newspaper symbol reappears and now it implies in addition 'these cases often tell of stress, hardship, and resulting friction.' Then a flash of something which signifies 'I incline toward that side.' Thus I proceed, shifting and developing my symbolic materials, falling into flashes of doubt, predilection, and uncertainty, with, finally, the words 'no decent method: I do not know,' and an accompanying conviction which reinforces the hopelessness of the quest with the limited knowledge at hand.

Here is another instance. 'Can space have an end?' Immediately I hazily see some one going on and on across a pathless expanse. This is an effort to come to the last station in space. Whenever the vague 'some one' stops, space spreads on and on. Always a new march. With a change in the direction, the result is the same. 'No,' I exclaim, 'space cannot have an end!' Whereupon verbal signs 'but space may be just certain

properties, and these properties may fail.' Then the flash 'Why not?' Not an ultimate solution, by any means; but I have thought: I have proposed; I have searched; and I have used symbols to advance the problem. A large problem to dispose of in so simple a way. True; but we have at hand all of the materials and procedures of thinking. The *value* of the solution does not concern us. Now let us try to reduce the operation to simpler terms.

The Main Stages in Thinking

Although recent researches upon thinking frequently run into the phraseology of logic, inventing all manner of new terms and alleging a wide variety of doubtful operations, we may sift out of them all the following essential stages in the elaborative functions: (1) the creation of a problem or task, (2) the advancement of the task by a determination, and, (3) the discovery and use of verbal and other symbols. Putting these requirements together, we may provisionally define the elaborative function as *a search initiated by a problem or task and carried on by the aid of symbolic materials.* The natural end of the function appears in the solution, just as the action is completed by an appropriate organic movement. But in either case the function may be in process whether or not it is finally resolved. It is the problem, its character, its origin, and the search for its solution, which primarily mark elaboration. As for the 'thought' itself, *i.e.,* for that bit of truth or falsehood, of knowledge or fiction, of belief or doubt, which emerges from the operations of thinking,—that may be left to the logician and the philosopher.

You will readily see, even from this condensed description, that elaborative thinking is one of the 'determined' functions. The adjective elaborative (laboring through) suggests just that. Unless there comes with the setting of the task an

active searching for a goal which is implied in the task, no thinking takes place. The task may be formulated as a query and left, as the resolve is in the unfinished action. Thinking tasks which the teacher hands on to less fertile students are problems ready to put into commission and handed over to another. Really to think, then, the student must make the task his own, must weave the task into a determination which faces a goal and carries the function in its direction, and must then find symbolic materials to advance the problem. Comparing our elaborative function with the other determined functions of the same general form (*i.e.,* action, emotion, and comprehension), we may write the general formula as follows:

Formulation of thought-task $\rangle$ Establishment of thought-determination $\rangle$ Discovery of symbolical means $\rangle$ Solution or defeat

Since elaboration is to involve for us a real search, we must exclude at the outset all those substitutes for thinking, those formulas, opinions, prejudices and traditions, which are current in human society and which bear superficially the marks of real solutions. So highly socialized is the organism that it is constantly adopting customary beliefs and expressing them as its own. 'What do you think'—we ask our neighbor—'of oriental rugs?' 'of cut glass?' 'of this political principle?' As a rule, the answer comes, not from thinking at all, but from a fixed concurrence in, or a remonstrance against, a prevailing opinion. Even the dissenter, who often appears to think because he dissents, may simply voice a determination to disagree with the group.

This simple formula of successive stages is not to be taken as an adequate account of all concrete instances of thinking, which are often much more complicated than the scheme suggests. The formula touches only the essential phases. An addi-

tional phase, which reminds us forcibly of the emotive course, is the appearance and clash of plural and rival determinations. Hard thinking frequently backs and fills. It sets out on one trial course, switches to another, see-saws, and finally moves on unless it is overcome by defeat. The switching and see-sawing correspond to the plural attempts at solving in the emotion (p. 233). The course of thinking is tortuous and irregular. That is because *the task is hard,* in the sense of recalcitrance. It often requires many attempts before it moves to the final stage. Here comes in the play of multiple shifts in determination, as illustrated a moment ago by the problem of the main cause of marital divorce. Wherever thinking runs into this form of blocking, we shall have to add to our formula (after "Establishment of thought determination") a stage of "Rise and fall of rival claimants." As this form of rivalry is a high hurdle in elaboration, it is as likely to be succeeded by 'defeat' as by 'solution,' save with the most skilled and practiced of thinkers.

Now we go on to treat each of these main stages in more detail.

The thinking task. Most persons look to others to set their tasks. Millions of men and women have their day's work set out for them when they report at office or factory in the morning. But thinking tasks cannot be handed around and prescribed in this fashion. To think one sets one's own task. That is a part of the thinking. And that is doubtless why thinking is a rare occupation. An individual who is able to pose and formulate sensible tasks for elaborative solution is usually able to proceed to the later stages and to come out with at least a small contribution to knowledge. Suppose the task for thought seeks a light metal which could be substituted for heavy steel. The statement of the task implies that the task-setter knows that the lighter substitute must possess certain indispensable properties and meet certain struc-

tural conditions. It is obvious that he is already on the way toward his solution. If the problem is to be turned over to another, it will be necessary that that other should go through a period of tuition in order that he may himself realize the problem. That applies also to the teacher who desires to set a student thinking. The task must somehow be one's own before thinking progresses to its subsequent stages. In this performance 'well begun is half done,' because the appreciation of the task begins at once to throw into commission a relevant determination.

Establishment of the determination. In action, as we saw, the determination is set for organic movement. The way to move, the time to move, and the coördination of movement with apprehended objects, make up the action-problem. In comprehension, the end is understanding. We gaze upon the new radio equipment, we revive the recent words and facial expression of our neighbor, we listen to the lecture, and we read recipes in order that we may know how to cook. When the task involves acquisition, the end is 'possession.' We repeat the lines, we run over our piano-scales and exercises, we follow instructions from the tutor in golf, in order that we may learn, use, and control. In a similar way, the determination of thinking is set toward the goal of *discovery.* Thinking is a search for knowledge and for conviction, and for knowledge and conviction which are not yet in the possession of the thinker.

Here we find the searching and inquisitive capabilities of the organism directed toward the solution of the most difficult form of problem which the living animal has approached. In man himself the function is usually rudimentary. Only here and there do we find that training has resulted in a free and competent employment of bodily resources in this direction. Most men and women seldom complete the first stage. University education itself is so much more seriously con-

cerned with inspection and comprehension that its senior students often succumb upon the approach of the first difficult trial of independent thinking. And society provides so many rules, opinions, prejudices, verbal formulas, and institutions that represent foregone conclusions and partisan preference that most men get on very well without the training and exercise of their elaborative functions. Where the fruits of real thinking are really demanded they can usually be borrowed, bought, or stolen from authentic sources. The inclination to search may then be indulged in other forms of occupation easier and pleasanter than hard thinking. [74]

Symbols employed in thinking. But if thinking is distinguished from the other determined functions by the direction in which the determination works itself out, it is also distinguished by the use which it makes of symbolic materials. The word, the wooden finger at the cross roads, the red light swinging in the street, the scrawled figure of skull and bones, and the disgusted shrug of the shoulder are symbolic. [75]

Symbols and symbolizing represent no new function of the organism. We had the first hint of something symbolic when we were discussing perceptive apprehension. It came when we noted that apprehending tended, under certain circumstances, to go beyond the object or event at hand. First, the present began to imply the not-quite-yet or the just-passing-away. Then it neglected the entire object to suggest an abstracted length, height, or color. Then its object was less the actual object at hand than any-of-this-kind, the general object. Inspection too moved away from the concrete presence to dig below the surface and to get at immediate implications; and comprehension, finally, frankly set up something to typify a topic.

Now what is the relation of all these departures from the main function of perceptive apprehension to symbols and symbolizing? It seems to be just this. When the apprehended

object or occurrence is replaced by some other product, that other product is said to be symbolized. An heroic female statue on a small island symbolizes liberty; a wooden cross symbolizes worship; the red lantern hung in the road symbolizes danger, and so on. The replacement is more or less complete. Sometimes less: the object simply indicates or stands for, without losing any of its own primary character. So mother-and-child suggesting maternity or the motherhood of Mary; a huge fly-wheel suggesting power; the advertised telephone suggesting convenience. Here the object points to something less concrete but does not give up its own identity or nature. At other times more complete: the object retires that the perceiver may note its reference. Here belong most forms of insignia implying membership in party, club, fraternity, or church. The fact that these objects are often made beautiful by expensive materials and ornamentation shows that they are not meant to be merely dead indicators. Finally, the use of words and of algebraical, logical, and physical signs presents a stage of reference where the symbol or sign can scarcely be said to be apprehended. Its own primary character as object is practically absorbed in its symbolizing use. There the psychological function becomes virtually pure comprehending or (as we shall later see) elaborative thinking. Perceiving has disappeared, although the eye is on the page or the ear is listening to the address or the telegraph-sounder. How far it has gone we learn when we attempt to read printers' proofs for typographical errors or treat the human voice as a series of tone-noise combinations, neglecting the linguistic significance.

Here, then, is a great new resource which frees the organism from the natural panorama and the order of nature, permitting it to deal with matters far removed from scene and sound. It is obvious that the gain lies not only in disengaging the organism from the flow of natural events as per-

ceived. It lies also in the creation of functional products which have extraordinary uses for man. Suppose that you could not get 'liberty,' 'worship,' 'danger,' 'maternity,' and ten thousand other symbolized things in the ways just enumerated. How *could* you get them? And wanting them, how could you proceed to understand all the topics in which these things are involved and proceed (this is the point to which we are coming) to think out all the problems with which these ten thousand symbolized things are bound up? The things thus symbolized comprise vast stores of psychological products upon which we constantly draw in comprehending, in emoving, in imagining, and in thinking, tapping the stores either by way of these symbolic media (words seen and heard, mathematical, logical and physical signs, etc.) or by way of the central substitutes for stimulus and receptor as we draw upon the products of learning and memorization.

Since you are better acquainted with this symbolizing procedure in perception, comprehension, imagination, and emotion, it will form a helpful introduction to the symbols of elaborative thinking if we consider the matter a little further in these better-known functions.

To see the swinging light at the rail-crossing before stopping the car does not require thinking. If it did, accidents would multiply. Perception itself contains symbolic reference, one object pointing to another by way of anticipation, filling out the perceptual field both in time and in space. And as perception passes over into comprehension, one of its main vehicles is the symbol. Then the object is not simply itself and not simply another anticipated object; it represents either its whole class or it stands for a topic. Thus the first cry of wild-fowl by night may mean 'the ducks have come' or 'autumn is approaching'; a shiny place upon the elbow 'this suit is wearing out' or 'writing is hard on clothes'; the heat of the June sun 'time for vacation.' Thus does understanding

itself make first-rate and frequent use of symbols; but we must not for that reason confuse it with real thinking.

Another confusion of thinking identifies it with imagination and with the employment therein of symbolic objects. Let me illustrate. After my house is built convenience suggests an additional swinging window. I consider putting in the window myself at odd moments. To this end I sit before the plastered wall, deciding where it should go and which way it is to swing. I roughly measure the space with my eye; I bring the square; I query whether I can build the facings plumb. A flash of an imaginary object means 'the lumber yard,' another flash 'the telephone.' I see the task as half completed, trying to anticipate difficulties which are new to me. Thus I begin with perception and action, working out my problem by way of imaginative apprehension. I may, of course, really think; but the chances are that other functions will suffice. That is to say, I conceive a problem and work it out on the basis of present perceived conditions by concrete alteration and construction, carried through in concrete imaginational terms.

But if symbols are created in perception, comprehension, and imagination, then what is the differentia here of real thinking? It is the novel use which is made of the symbol. The signboard symbol is incorporated into the perception or the action; the Niobe symbol into my understanding and into my emotion of pity; but thinking uses the symbol for the production of new knowledge, or to bring a conviction or assent.

'Why'—I ask myself—'do these catalpa trees grow brown at the same time that the autumnal rains are refreshing the shrubs and turning the somber fields to green?' My botanical information is not sufficient for a good answer; but I can note what does come when I raise the problem. An imagined object 'rusty and half-naked trees,' which symbolizes 'decay

in autumn,' is accompanied by the verbal signs 'deciduous... annual changes... independent of rain,' and by an imaginational apprehension of two vague lines running in opposite directions whose symbolic references are 'toward spring' and 'toward autumn.' Presently I come out with the general conclusion that there is no real contradiction in nature but that different conditions of life produce unlike effects under the same conditions of climate and weather.

Take another instance. There is proposed the problem: 'Will it rain tomorrow?' I may answer the question without thinking; for I may say, 'Yes, it feels like rain,' or 'Yes, it always rains when I plan to be out of doors,' or 'No, the morning paper predicts clear weather.' But suppose that I do think; that I get the weather-map and examine the sweeping concentric lines; that I pass to their symbolic significance, 'a low pressure area,' 'a steep barometric gradient,' 'high winds to the south.' These symbolic objects are put together under the problem, organized, and then new knowledge and the conviction 'Yes, rain ahead' emerge.

We have spoken of the creation of new knowledge; but of course thought is not made from nothing. Were it not for the past, we could not so much as propose a thought-problem. The young child, the cub, and the chick have literally nothing to think out. They may be startled, or inquisitive, or curious; but they do not propound to themselves questions which demand thinking for an answer. So to propound implies that the organism already has knowledge which it seeks to extend. The thought-determination always is rooted in the individual's past experiences. There are no inherited thought-problems; though the equipment of one individual organism for advancing problems once begun may be vastly better than that of another. All thinking is a *prepared* function; the train for it has been laid in the past. Thus we must always include bodily trends and we must

always take the individual history into account. In the recent example of an unending space, of going on and on, of existence beyond the dome of the heavens, and the like, our thinking is prepared in such a way that the preparation now touches off the threadlike items which appear. An earthquake, as Madame Defarge observed, comes and goes very suddenly, but it is a long time in the making.

We say of those actions of the new-born animal which are performed straightway and without tuition that they are racially or prenatally prepared. Just as much are the elaborative functions made possible by the past—not the racial past, in this case, but—the individual past. To search, to propound, to gather material, and to deal abstractly by way of symbolized objects presuppose antecedent knowledge and antecedent search.

The Employment of the Flash in Thinking

If you are on terms of intimacy with your own private thinking, you will have observed that the advances in the process and also the thought-products frequently appear in sudden bits or fragments. Some of these bits appear in verbal form, *e.g.*, 'now I'm getting it,' 'suppose I divide this by this,' 'this *is* the tooth of an early proboscidean,' 'I'm on the wrong track,' 'that will balance the budget.' Sometimes the fragment comes in a single ejaculation; 'ah!' 'perhaps!' 'good!' 'no!' 'at last!' 'chlorine in it!' and the like. But at other times no words appear, no significant pictures or sounds are present, and yet the thinking takes a turn and you realize that the problem is getting on. Men who found these 'imageless' flashes announced that they had discovered 'imageless thought.' The announcement was exciting and a little shocking—shocking because most psychologists then held that 'conscious processes' of the 'image' sort did all the thinking, so that thought without images seemed contradictory. Sensations and images were

mental objects which 'carried meaning' and meaning was the outcome of thinking. But here, in 'imageless thought,' was meaning with no mental things to support and to 'carry' it.

Since we find that *the body thinks* as well as perceives, understands, and all the rest, we have no trouble with 'imageless thinking,' except that the term is obscure and ambiguous. The body manages the flashes as well as it does the long slow process of proceeding from premises to conclusions, the process which formal logic would have us believe to be a standard and orthodox manner of thinking.

Now the flashes do really become significant where thought is said to be close-packed, as meat is in the nut. The course of all the functions is punctuated by little jumps and turns of information, doubt, assurance, hesitation, and valuation of all sorts (social, personal, and aesthetic). Where the symbol is neither verbal nor object-like (imaginal) we speak of the symbolization as a flash. Anyone who has innocently opened the platform-door of a lecture-hall and found himself, to his dismay, suddenly confronted by hundreds of disturbed listeners will understand what the writers mean by at least one form of the flash. In that case it will be the flash of consternation and embarrassment which, translated into words, would run: 'Here I am; what a fool; they all glare; why did I? how can I escape?' The flash is a kind of shock of knowledge, conviction, or emotion. An enormous significance suddenly appears without imaginal picture and without words. The incidents and turns of a heated argument also offer a fertile field in which to search for flashes. When translated into words they run: 'I have made my point,' 'that was an unfortunate admission,' 'he is not convinced, 'I am sure of my ground,' etc. [76]

Unfortunately the physiologist, the neurologist, and other students of bodily process have been able to tell us very little about the somatic means of advancing and criticizing thought

in this sudden flashing and insightful manner. Instead of a descriptive account, therefore, we shall have to content ourselves with two or three comments. (1) In thinking, the flash depends upon the thought-task, just as the resolution through movement depends upon the action-task. It is, so to say, the thought-task which gives head and driving power to the flash. The now-I-have-it flash or the going-on-and-on-in-space flash is informed with relevance and significance only under the task to be solved. (2) Although the alleged marvels of 'incubation' and 'unconscious thinking' are easily overdone, it does appear that vestiges or surrogates of the thought-task may be actively present while the organism turns to other physiological and psychological employments. Poincaré noted the sudden flashing illuminations which came to his thinking while otherwise engaged, the solutions which refuse to come while the organism obviously drives ahead with the problem. These undercurrents of specific and determined functioning are known to all of us in the lapses of haunting and disturbing problems which hang over us without solution for days and weeks together. (3) It has been found possible to trace historically a few flashes toward their probable origin. There we find that gestures, bodily poses, visceral turnings, gasping, holding the breath, and wrinkling the forehead tend, when repeated, toward abbreviation and condensation, and also—this is the most important point—they tend to assume symbolic reference. Instead of simply reporting how the organism is 'held' or 'disposed,' the flash marks the progress of thinking by a doubt, a shade of indecision, a feel for the correct answer, a conviction that the alleged fact is true, a shock of surprise, and so on and on. Since the flash *indicates,* we might call its symbolic reference an *indicatory transfer.*

We must remember, however, that if these sudden fleeting states were not sustained by the entire living organism, thinking would be without relevance and without issue. The

flashes chiefly supply emphasis and comment, setting affirmation, denial, query, suspicion, and certitude at appropriate stages in the elaborative procedure. They announce, so to say, from moment to moment, the position of the organism upon matters at issue. Assume one after another a dozen of these muscular, abdominal, and thoracic posings and posturings, and you will find that most of the dozen wear an aspect of signification strongly suggesting the turns and flashings of understanding and thinking. When you mimic the threatened intruder to the Scottish Highlands

—His back against the rock he bore
And firmly placed his foot before—

you are all defiance and vigor; when breath goes out and chin falls, you despair of the solution; and when the vascular thrill of the Grand Canyon or the Alps runs through you, you are obviously getting on and about to resolve your problem. Thus do the general and the special temperings of life, as they affect muscle, tendon, and viscus, come into use, not only in simple action, in emotion, and in perception, but also do they make their major contributions to the most complex and the most difficult of all the psychological functions, the function of elaborative thinking. Fortunate and effective the student, the professional man, or the man of affairs who has trained his body to the supreme accomplishment of this operation!

Everyday and Laboratory Instances of Thinking

Let us see how far we can apply the knowledge which we have derived to such familiar and common instances as we might take from thinking in the streets, in a collegiate examination, or in such a practical matter as the attempt to discover why the right front tire of a car wears out more rapidly than its mate. Here we neither borrow and assimilate the

thinking-task nor do we accept it in the formal instruction, as in the experiments on action and comprehension. We formulate the thought-problem ourselves. Surprise at finding that the new tire must be bought, when we had expected the old one to wear another season, may well be food for thought.

There is food, likewise, in the shedding of the leaves in autumn or in the necessity of finding a way to adjust living expenses to a reduced income. Sometimes we say of a person that he is thoughtful in the sense that he is always turning up new problems for solution. He has intellectual curiosity. He constantly wants to 'know why.'

Of course, even an intellectual person may satisfy his curiosity by substitutive means and not think at all. 'How were the battle lines formed at Vimy Ridge?' 'Why is my neighbor's car standing so long at *his* neighbor's door?' 'What can I procure for the family luncheon within an hour?' These problems are real enough; but they are solved, as a rule, without elaboration and often without symbols of any kind.

Neither does abstractive perception or comprehension necessarily lead on to thinking—as we have seen. One may, to be sure, come by way of elaboration upon an abstractive view of an object, *e.g.*, the composition of the earth's filling or the chemical ingredients of the chromatin threads; but that is only because perceiving and comprehending meet with insuperable difficulties. There the abstracted thing is a product of thinking. But mere departure from the whole concrete object does not necessarily—or even usually—imply thinking.

Nor does—as we urged in the last chapter—the mere denoting of a class or species (as man, animal, beauty) necessarily involve thinking. It belongs rather to a mode of comprehension; although, again, the concept *may be* either an instrument or an issue of thinking. In fact, many of our

most familiar concepts are frequently used in, and modified by, thinking, as we shall presently see. As for the concept itself (considered apart from its use in logic), it is simply the most refined and the most inclusive of symbols. Instead of referring to a simple apprehendable object (*e.g.*, Luther McIntyre of New York City), it denotes either a certain kind of object or event (beetle, star, fishing, running, swimming), or an assumed force, condition, or agency (energy, field of force, life) which may never have been itself apprehended, but which helps us to understand and discuss our existence and the world in which we live.

Finally, remind yourself again that the verbal construction which logicians call the judgment is not—at least in its common forms—a mode of thinking. The primary and common function expressed in the judgment is either (1) a concrete perception or inspection ('That tie is a brilliant red,' 'This water looks cold') or (2) the comprehension of words of a speaker or writer ('For he is free to whom all happens agreeably to his desire, and whom no one can unduly restrain.' 'This world was once a fluid haze of light'). In the latter kind of judgment the speaker or writer proposes a topic. The function left to the reader or hearer is to comprehend.

But with all these substitutes and all the simpler devices, there is no doubt that the ability to devise new thought-problems, to sustain the thought-determination, to procure the symbolic materials necessary to solution, and to make sensible and coherent use of the fruits of real thinking is one of the major abilities and one of the great acquirements of the human adult.

As regards the place of the task in the solution, both laboratory studies and our common thinking reveal three main cases. (1) First, the task may run through the solution. When I observed last week the early wear of the right front tire and asked 'why?' I straightway attempted a solution, main-

taining the task meanwhile and refreshing it by comment: 'That is curious!' 'Strange, isn't it!' 'How can that be?' I examined the wheels, the road, the curb, and the driver's view of the track (inspection). I recalled what I had heard at garages and tire-stores (memory). I symbolized the driving, turning, backing (imagination). I enriched the topic 'wheel-wear' by related material (comprehension) until finally I came symbolically upon the solution: 'The right wheel runs over rougher ground at the edge of the road, bumps curbs, and gets more lateral thrust from the crowning of the roadway.' There the query sustained itself until the end, where task and elaboration were discharged together.

(2) In the second case, the task is transformed into a device for solution, the device standing as a surrogate for the original problem. This is illustrated by tapping the interior of the Pullman car to discover whether the frame is wood or steel. Instead of the original problem 'Is it steel or wood?' we have the self-instruction 'tap it,' relying upon the sound to arouse the words 'a wood-sound' or 'the ring of steel.' This method of thinking is common in classificatory science. The entomologist who is intent upon the identification of a specimen may replace the original task of classifying by an intent to notice the venation of the wings or the structure of the mandibles.

(3) In the final case, the problem appears to lapse, but is sustained by some unobservable bodily trend, and the solution springs out unheralded, as when the skillful surgeon gains new anatomical knowledge while he attentively operates. Always the organism is prepared. It is charged. A problem has at some time been formulated; at least partially. Now the ordinary issue of elaboration appears; although the functional antecedents are wanting so far as the formulated task is concerned.

In order to bring this third case within the laboratory, we should compose the observer (with closed eyes) be-

fore an exposure-screen and then instruct him as follows: "As I read to you a statement, consider the problem which the reading implies. When you understand the problem, lift your right hand." Then such a statement as this is read: "How does the effect of flowing ice on land-surfaces differ in the glacial stream of a valley and in the ice-field extending over a continental table-land?" Upon receiving the signal, the experimenter presents upon the screen a series of words, some of which are designed to give hints toward the solution. Within the series will appear such words as 'Alps,' 'grinding,' 'thawing,' 'prairie,' 'Middle West,' 'torrents,' 'boulder,' 'flat deposits,' 'eons,' 'sunshine,' etc., commingled with many words which make no reference to the thinking-task. The series is presented with the caution: "Forget the task for the present. Read the words carefully for I shall later ask you to repeat them in order."

The problem must be carefully adapted to the knowledge and the limits of knowledge of the observer. In those cases where the experiment succeeds, the verbal symbols and the materials which they bring with them (imagined objects, flashes, memories, and the like) will serve the problem and subsequently lead to full or partial solutions. The experiment requires, as you can well imagine, capable and trained observers. It also implies that the experimenter himself has made the devising of the exercise a serious thinking-task of his own, well in advance of the hours of actual observation. Our third case will be exemplified, of course, only by those instances where a solution (right or wrong) springs out when the task itself exists only in the form of priming and the organism is otherwise engaged.

The Labor of Thinking

A critical scrutiny at first-hand will reveal all manner of failures, half solutions, delays, and reformulations in think-

ing. If you have recently broken your head over some knotty problem, you may be inclined to say that 'the course of true thought never did run smooth.' It is probably the exception rather than the rule that a really new thought-task should immediately, upon its initial determination, supply all the resources necessary to a complete and unimpeded elaboration. Such instances as Newton with the falling apple and Galileo with his swinging lamp are usually fictions of the historian or of the logician, in so far as they pretend to show the direct and immediate march of thought to a new solution. At the most, they are, in all probability, only final formulations behind which stand months or years of preparation and of abortive attempts at discovery. Outside the laboratory the task itself is very often not given in as clear-cut and definite terms as it is in the experiments and thus it may require many successive attempts at clear formulation before it really succeeds.

But while the making up of our serious thought-tasks is often much more laborious and complicated than the simple experimental instances, the procedure appears to be the same. The combined functions of apprehension and comprehension with search clarify the materials at hand while an appropriate determination holds the function in course and thus serves to advance the problem.

Consider another instance taken from daily life. I visit an institution designed for the care of defective children. Upon entering I vaguely note that I am facing a new problem. I converse with the superintendent, the physicians, examiners, and attendants. I visit the wards and cottages. I distinguish the moron, the idiot, and the child suffering slight enfeeblement. I watch the inmates at play, at work, and at table. I note the wide variations of movement, expression, and physical deformity. I consider history, family reasons for commitment, and custodial provisions by the state. Gradually

is enriched and consolidated the topic 'condition and care of defectives,' and out of it, by perceiving, inspecting, and comprehending, emerges the problem, *'What is the obligation of the state?'* One might simply search among existing ready-made formulas. 'Why care for the useless?' and the like. But this sort of borrowing is impossible because of the richness and the particularity of the topic. The next step is the use of an old solution, 'Why worry!' 'Plato has solved the problem in his ideal Republic,' 'Let families muddle along with their unfortunate offspring,' or 'This plan seems to work.' It is obvious that such a procedure (common enough in these problems!) only avoids thought. The problem is killed before it is really formulated and faced. Let us take the position that the topic engenders a thought-task and honestly try to carry it through.

Notice first that the problem comes out in general and fairly abstruse terms. This result is common where the topic is rich and many-sided. Such subjects call for abstraction and for the use of our super-symbol, the concept. Without such aids we should be lost in a wilderness of perceptual details and of verbal trains. The individuals observed are regarded as examples or typical instances (exemplificatory perception). The perceiver abstracts from all those aspects of the patients which serve only to make them multitudinous and cumbersome; so also the cottages, the kitchens, the attendants, and the officers. On the other hand, the concepts of state, public resources, legislation, duty, social hygiene, disease, mental defect, and inheritance are necessary, not only to an apt and competent solution but to the very formulation of the thought-problem itself. A practical demonstration of this dependence is presented by the history of public custody and care. The more clearly the public (or that small fraction of it which thinks) has been able to sustain its relevant concepts, the more

aptly and intelligently has it been able to conceive such problems as the nature of psychological defect and civic responsibility.

A similar analysis might be made of persistent and fundamental problems of the sciences. Generation after generation the sciences repeat the questions, 'What is life?' 'How is matter constituted?' 'How does the fertilized germ-cell develop?' 'What historical relations do animals sustain to each other?' and the like. Although the formal statement of the scientific problem may remain always the same, its actual import grows with the enrichment of the topic through increasing knowledge and with the conceptual refinements which improve our understanding of life, animals, matter, and the rest.

It frequently happens, of course, that the factual materials for constructing the task are not always so easy of access as in our case of custodial care. Generations may struggle blindly toward the statement of a problem (*e.g.*, 'What is the nature of the apparent attraction of one body for another?' 'What is the relation of seasonal change to the earth's motions?' 'What governs the weather?') until new facts and other solutions have made a clear formulation possible. It not infrequently happens that obfuscation is increased and a clear formulation delayed by emotion, magical belief, ardent desire, and prejudice.

The inaptitudes, the delays, the obscurities, and the half-successes of the elaborative functions have led some writers to declare that thinking is a stumbling and blind process of trial and error. This view is too extreme; it overlooks the fact that, in spite of its limitations in reaching *correct and useful* conclusions, thinking is a determined and directive approach, by way of a formulated task, to an anticipated solution.

The Benefits of Thinking

The benefits of thinking proceed naturally from the character of the elaborative functions. Thus to entertain a thought-problem we must pass beyond mere apprehension, whether of things absent or present, beyond action, beyond comprehension itself, to regard a certain significance in things. The chief benefits to the individual we may set down as four.

(1) In the first place, thinking brings us *new knowledge, i.e.,* knowledge of a new order, significant relations and hidden resemblances—in a word, knowledge which displays the nature of things. Of course, the single individual acquires directly by thinking only a small part of the total store. Larger stores he acquires by way of comprehension from the thinking of other men. But without his own individual thinking, his comprehension is straitly limited, and his critical estimation of facts and theories is without value.

(2) Because of the departure of the thought-product from the concrete object and the particular occurrence, the individual is carried beyond the fixed orders of space and time, the immediate stage-setting of life, to a more spacious view of the universe. This freedom from the fixed order gives *foresight.* The thinker outruns time. The present and the past are not only succeeding acts in a drama; they point to that which may some time be done. By thinking, man anticipates the future and provides against it, building cities and railroads, cultivating the land, and contriving (as he hopes!) an enduring arrangement of social and political relations.

(3) Insightful knowledge of the nature of things, together with foresight, leads to *valuation.* The abstract regard of human relations and the anticipation of human needs prompt the estimation of objects and acts as good or bad, as right or wrong, as praiseworthy or worthy of condemnation, as true or false, beautiful or ugly, important or trivial. So man adds

values to his world of objects and occurrences, of action and predicament.

(4) Finally, thinking furnishes a kind of *training* not otherwise supplied. We saw that, even in simple tasks, the solution of one problem helps in the solution of another; that the exercise of function leads to general methods which remain for new problems. To put the matter in wider terms, thinking adds a new resource both by way of new knowledge and by the acquisition of methods which will propound and solve future problems. Without fixed habits of thinking, the judge is a mere partisan or a mere sentimentalist, the legislator a mere echo of political opinion, and the scholar a mere transcriber of borrowed thoughts.

The benefits of thinking, then, are great; but they are to be enjoyed only by hard labor. Thinking easily goes wrong. The illusions of the senses, through inadequate perception, we may learn to correct; but the employment of symbolic materials in elaborative solutions requires high powers and the cunning use of means and devices. When we consider these intrinsic difficulties and also the natural bias of wish, desire, and current opinion, we can at least vaguely understand why false doctrines, magical explanations, and superstitious beliefs flourish in spite of centuries of science. We must then agree with John Locke that thinking requires great care 'to conduct it aright in the search of knowledge.'

The Question of a Valuating Function

So much of our commerce with human beings and with nature rests upon the pronouncement of values that the common assumption of a special 'valuing capacity' or power should not surprise us. Constantly we pass judgment upon objects, persons, principles, and human actions. These acts are pronouncements of worth. How are they made? When we value, do we do something distinctive? Is there a separate

functional mode which provides for the setting of things up or down, for rating them as higher or lower, for prizing and disprizing them, for labeling them as objects of great or of little worth?

The first important fact for the psychology of value (leaving aside all attempts at classification of value and all matters which pertain to morals, aesthetics, logic, and metaphysics) is the obvious fact that a value always qualifies some functional product. I perceive the tree as existing and as displaying certain existential attributes (greenness, height, spread, etc.). I also perceive it as symmetrical, graceful, and badly placed. These last meanings of the tree value it; they mark it up or mark it down. But they are qualifications of the tree as much as the others, although we quarrel oftener about their validity. In a similar way, the conviction of truth comes out of an operation of thought as naturally as a new relation or a new law comes. What is still more important for our present discussion is the fact that the values are derived through the same functions as our thoughts, topics of information, coördinated movements, and objects of apprehension. That is to say, we *perceive and imagine* values, we acquire values by *action and emotion,* we *comprehend* values through topical inquiry, and we *think out* values in the specific manner which we have just expounded.

Those who hold to a rational, an emotional, or a sensuous theory of value are likely to overlook the fact that all the fundamental functions are laid under levy in the creation of the valuational side of the world. Music and the fine arts would hardly prosper without apprehension; or dancing, sculpture, and pantomime without action. The art of prose composition rests in part upon comprehension, and no first-hand discovery of moral or aesthetic order succeeds without thinking.

A fuller account of values than is feasible in this place

would distinguish such psychological classes as (1) *spurious valuations,* which are taken on trust or else at the dictate of custom, fashion, or some other convention, *i.e.,* borrowed values, without appreciation and without an appropriate problem or task; (2) those *spontaneous valuations* which rest upon special predispositions and valuing flashes and which are gradually consolidated and systematized under cultural conditions; and (3) those *reasonable values* which are wrought out under the tasks of comprehending and thinking.

Bodily Resources and Government of Thinking

Those who define thinking as 'a substitutive action,' or as 'language,' or as 'subvocal speech'; as the 'entertaining of images,' 'the use of ideas,' or 'a form of implicit reaction' will variously seek in the body or the mind for the means of thinking. Under our conception and definition no less does the question press for an answer. A partial answer is suggested by the reflection that in elaborative thinking are involved all other psychological functions. So far as we know the bodily bases of these, so far do we know how the organism manages to think. This knowledge is—as we have seen all the way through the book—exceedingly imperfect and inadequate. But when we ask further how the body manages the new kind of integration of perceiving, inspecting, comprehending, and the rest—which is the essence of thinking—we pose a still more difficult problem, a problem which the physiologist and the neurologist have scarcely given serious consideration with the psychological facts set clearly before them.

For the thinking task, the body is widely drawn upon, with, it may be, a specific extension of cerebral function in a direction which we do not know. As for the determination, there would seem to be nothing more involved on the somatic side than is involved in all those persisting and directive

activities of nerve, muscle, and brain, which hold a given function or group of functions in course. As for the command of materials which the thinker uses in a referred and symbolical manner, we have scarcely a hint from the students of the body. When it is solved on the cerebral side, it will probably be solved by taking instances which are much simpler than those symbols which are imbedded in the intermediate stages of elaborative thinking.

The problem of government in thinking is almost as difficult as that of immediate bodily resource. Even more than in inspecting and comprehending, do the organic sources of government overtop and subordinate the external and non-organic sources. To be sure, occasions present problems for thought, and human beings and human affairs incite the individual to think; but no matter how urgent the demand, no organism thinks in the elaborative way which is not a thinking organism; which is not—that is to say—trained, primed, and prepared for this difficult feat. The historical sources are therefore also primary and essential. Not only must there be 'stores of knowledge' in the special sense which the text has explained; there must be a functional aptitude which is just as necessary as the aptitude required in playing the violin or in making a respectable score at golf. Were we to follow backward through the years of tuition, we should probably find (unfortunately no one has yet searched with diligence) that the same factors and incidents of learning that we discovered in action and the other simpler functions also appear in the gradual processes by which the thinker is made through the years of childhood, adolescence, and adult maturity.

CHAPTER X

FUNCTIONAL COMPONENTS AND RESULTANTS IN DAILY LIVING

We set out upon our quest for the primary and basal psychological functions with the remark that the human organism does a very great number of things in the course of the day by the employment of a comparatively small number of fundamental operations. About half of the operations of the organism we have accorded to the physiologist and other biological students of life, noting the suitability in method and training of these men for the study and description of the functions which naturally fall to them. Following a general custom, we called these functions physiological and we reserved the rest for the psychologist. Since the psychologist's concern is with fairly distinctive performances of the living being, it appeared sensible to call the modes of the performance falling to him psychological functions. Here we have not merely included the motor activities and their resultants in the form of behavior but rather have observed precisely how the organism is active from moment to moment and precisely what are the conditions and the products of activity.

In spite of the great number of performances which are left to the psychologist, it has seemed to be possible to reduce all of them to less than a dozen ultimate and basal modes of function. The description of these—taking them one after another—we have now completed. We have also tried to discover how the living body contrives each of them out of its own resources, leaving nothing to conscious or unconscious

agencies and forces and nothing to the biologist's faculties of habit, instinct, and memorial storage.

Now if our quest has been moderately successful, if we have discovered and described all of the generic modes of operation, it should be possible to return to our initial multiplicity presented in the detailed activities of living and to exhaust them in terms of our basal modes. Thus to translate all of the activities of daily life into primary functions would plainly transcend the writer's limits and doubtless transcend likewise the reader's patience. All that we shall attempt in this final chapter is to examine only a few typical occupations of the day and to be content with their reduction to our psychological forms. Those to be selected are conversing, arranging, exploring, and studying. We shall show that these typical occupations involve our now familiar functions, combined in various ways, and leading on to characteristic issues or products.

Before we proceed to this task, however, it will be necessary to consider, in a more general and perspective way than we have had occasion to do, the close relations which obtain among the functions themselves. As early as the first chapter we discovered that the functions all displayed family relations with each other; that perceiving and acting came from a common ancestor; that inspecting and comprehending sprang from perceiving and acting; that emotion and action were of the same general executive type; that search ran through all; and that every other function was imbedded in the latest and most complex, namely, elaborative thinking. If we find, therefore, that two, three, or even more of the functions are concerned in each of the four gross occupations which we have chosen for special examination, we shall have no cause for surprise or perplexity.

Another way in which the family resemblance appears among the functions lies in certain characteristics common to

all. These characteristics have not until now been described at large because the description has proceeded function by function. But now we must examine all of them together in search of these common features.

Common Characteristics of the Psychological Functions

The outstanding characteristics are *pattern, clarity,* and *dominance.* The inquiry will fall into two parts. The first will examine the *pattern aspect of function* as it appears in the several forms; the second will dwell upon the facts of *clarity* and *of dominance* as these appear within the pattern and in the passage from stage to stage as a given function runs itself through. This second part will also inquire into the way in which the unpatterned functions are carried out and discharged.

The pattern-aspect of the functions. We acquired in the earlier chapters much detailed knowledge of this patterned side of the apprehensive functions. We found that, in perceiving, stimulus and receptor release neural impulses running toward the central nervous system in an orderly array which represent (with certain changes) characteristics of the perceived object; thus retinal spread and the form and extent of the visually apprehended object; thus vibrational rate and the pitch and clang of the sound-object; thus translation over the eye or skin and the perception of movement; thus somaesthetic complexes and the perception of bodily state and posture. These orderly arrays in stimulus and receptor, therefore, have had a hand in the constitution of the objects which have been thus characteristically announced to the organism. Of course this parallelism has been far from complete, the body itself modifying the pattern from various other sources; but when we related the qualities to the underlying facts of receptorial incitement under stimulation (Chapter iv) we were convinced that the definite order thus introduced in neural impulses from

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(shall we say?) the order of nature was responsible for the first stirrings of the apprehensive activities of the body. We must not, however, overlook those perceivings (movement, bodily states, posturings, and rapid modifications of quality) where pattern tends to recede and undifferentiated change or gross state to replace it.

Passing on to the other forms of apprehension (remembering and imagining) we again discovered enough of the original patterning to make it appear that these bodily activities, once initiated as we have explained, remained when the primary incitement was essentially cut off and thus gave rise to the two modified forms of apprehending. To be sure, other receptors, notably those from the interior of the body (proprioceptors and interoceptors), lent their aid, remodeling the pattern; but the main outline of the original stood, stamping the perceived, remembered, or imagined object with a fixed character, and thus creating, by way of these facile functions, the worlds of remembrance and anticipation, of fantasy, and —to some extent—the world of art, of literature, and of invention.

When we advanced to the executive functions we found that patterning appears in a different way. So far as apprehension is embodied in action, we found *the scene* of the action articulated; but so far as the action was a determination, it was unpatterned. All of those actions, therefore, where the sensory or apprehensive side suffers foreshortening and partial eclipse tend to be unpatterned. The 'muscular' and automatized forms are cases in point. Here the function is mainly a running on toward the completing movement. But when the determination is equivocal, divided (as in choice), or in any way blocked, there the pattern inclines toward reinstatement and elaboration. The lower limit appears in those actions, long practiced, where the movement is touched off with only a flicker of 'scenery,' as when the bare glimpse of

something-moving-in-the-bushes brings the gun to the shoulder and the finger to the trigger.

In working through the emotive predicament, it was again the scene—this time the dramatic scene—that supplied pattern to the function. The feared animal or rival must be somehow apprehended in order that the fearful predicament may arise; and the same is true of dreadful, anxious, enraging, perplexing, and other emotive scenes and occasions. Here pattern is more central than in acting; for the loss of the dramatic scene destroys the predicament, attempts at resolution cease, and nothing more than mood is left. Mood is in fact a variant of function which well illustrates an operation lacking in pattern. Its only rival in this regard is pure search, wherein pattern is almost wholly wanting. It may be that there are, in the disorders, 'objectless' terrors, anxieties, and the like; but in them the visceral and autonomic posturings of the body would seem to carry (substituting a part for the whole) the predicamental seizure without a 'scene.' Certain afflictions of the heart are said also to bring an unnamable fear or anxiety which marks a real emotion. On the tumultuous side of baffle and unsuccess, which appears in the third stage of emoving, pattern tends to recede—as we might expect—for here the determinative aspect of the function is uppermost.

The apprehending ingredients of inspecting and comprehending showed pattern, while the search, the digging-in, and the departure from the scene by way of abstractive reference and symbolizing, lacked the articulated part.

Elaborative thinking, finally, was seen to be a function of many origins, making its greedy draught upon all the others. Thus, *e.g.*, a *perceived* object, to which *inspection* accredits novel features, may elicit an act of *comprehension*, and so set a thought-problem to which *search* may bring symbols appropriate to a solution. I see a marbled surface (perception), detect a fixed line-pattern upon its surface (inspection), bring

it into the class of artificially-made (understanding), and work through, by a symbolic shorthand of contrived tools and processes, the probable mode of its manufacture and staining (elaborative thinking). An instance nearer at hand is your reading of this very page, during which comprehension will (let us hope!) be the central function brought to your service, but a function which may be greatly sustained and reënforced by bits of elaboration.

In thinking, pattern is almost wholly confined to the pictorial forms of the task and to the incidental complexes which serve as concrete sign-posts to direct the thinking in its course. The comprehending moments, the flashes, the symbolizing references, and above all the directed determination, are almost entirely of the unpatterned sort. Taking this elaborative function in its entirety, then, we observe that it is chiefly and essentially an unarticulated and patternless performance. It is small wonder, therefore, that the eager analysts who sought to dismember it into 'sensations' and 'images' met with failure.

Looking at all these psychological functions and at the bodily support of them, can we make a generalization about their patterned and unpatterned aspects? Perhaps we may say that so far as a given function is primarily determined by stimuli attacking the nervous system in articulated spatial and temporal forms (as in most 'visual' and 'auditory' perceivings), and where the chemical detail of object or life-process is effective at the receptors (as in taste and smell perceivings and in visceral feels of bodily state), there the functions are patterned. Again we may also suggest, on the other side, that *a change* of spatial or temporal stimulation (as in movement-perceptions) or an organic stir-up which affects the interoceptors (as in dizziness or intestinal distress) leads to undifferentiated activities. That is to say that where the muscles (striped and plain), the glands, and the viscera

are called into requisition for psychological functioning, there the functioning is chiefly unpatterned. And since these parts of the body supply direction, determination, and 'drive' to the operations, we shall find those functions most nearly devoid of patterning where the forward-tending aspects are most prominent, *i.e.*, in skilled action, comprehending, mood, and thinking. Whatever the differential bodily conditions, however, the presence or absence of articulation is a general characteristic of the processes with which the psychologist is deeply concerned. [77]

Clarity and dominance. Here we shall have to settle our accounts with the topic of attention, bringing this difficult subject into accord with our functional point of view. We must take our bearings from the facts and not yield to the allurements of a mental force which supervises and manages the affairs of the organism, mysteriously assorting its activities and directing its ways. Such a dynamic and governing faculty of attention is common in popular and applied psychology and it frequently insinuates itself into the general textbooks. It is certainly implied when the school teacher chides the idle or dull student for being inattentive to his tasks and when one regards oneself as efficient by way of 'giving strict attention.' Attention thus considered as an ally, a whip, or a duty, is of great practical and pedagogical importance; but we can scarcely adopt it here in a psychological context. Let us look instead at the relevant facts.

When you lift your eyes from the page and allow them to roam about the room and to scan from the window the panorama of passing cars, swaying trees, and dripping eaves, you will at once realize that your perceptive apprehension is constantly shifting from one thing to another, from bookshelves to clock-face, from blazing hearth to fluttering shadow on the ceiling, from wind-blown branches to drip-drip of rain. And if you will now pause at any point in this kaleido-

scopic change of scene, close your eyes, and consider the details of perceiving, you will discover that it is less the whole panorama that obviously undergoes change than smaller areas of emphasis. You have here a series of perceptive trains, the whole more or less ligated, but each phase of it containing a pattern which holds a sort of distinction within a larger framework. When we regard the wide range of appeal made to the body at any moment and under every circumstance, we realize that many more stimuli confront the organism than the organism can care for by way of its receptors and its central nervous system. Light, sound, a variety of tactual impressions, and all manner of incitement from the processes of digesting, breathing, and muscular activity are constantly attacking the body from within and without. And, in addition to all these appeals, there frequently are matters under way which the organism is in process of carrying through. On a suitable occasion you look out expecting the arrival of a guest; or you are annoyed at the swift passage of time and glance at the clock to verify the hour; you try to hear a whispered conversation in the hall or you bend to a half-done task in order to be ready for dinner.

It appears, then, that, besides the passing show, the exigencies of the organism, as well as performances already-in-course, stand behind the direction, the rate, and the coloring of the patterned flow of function. We say easily that 'we attend to this and that'; but what we really want to know in this connection is what 'attending to' means in terms of the functions and of the bodily resources which keep the functions going as they do go. There is an orderliness here, and the orderliness suggests that the body is going about its business with a certain degree of freedom from the physical flow of events. It is obvious that certain appeals to the organism are favored and also that the organism is commanding its own affairs and getting on with its work.

We shall understand our facts only by keeping in view both the pattern side of the functions and the directive course which appears most clearly in the forms which we have indicated, but which is always a factor in psychological performance of every kind.

First let us closely scrutinize our patterns.

At once we notice that the pattern is limited in extent. If you attempt at the same time to count the passing cars, to discover by moving your toes just where the intruding nail has broken through the sole, to get the hour-stroke of the clock, and to remember where you left your umbrella, you will fail. To succeed you must either take these tasks one by one in order or else somehow consolidate them into one. *Every psychological function is limited.* This fact of limit has suggested a great number of experiments for the psychological laboratory. Once definite conditions are set for a given function, the experimenter is able to determine in a very precise way just what a given limit is. To be sure, the limit is not independent of the occasion or of the state of the organism. A slight shift of conditions (*e.g.*, a change of light on the reading, the plot of the play, acquaintance with the subject of which we are thinking) is almost certain to shift the limits. The speed of the automobile changes in the same way with change of oil and gasoline, temperature, head winds, position of the spark, and so on. But in both cases, there are always functional limits. The living organism is invariably restricted in the rate and the output of any and every performance—biological or psychological—which it undertakes. It is limited by the circumstances of the moment, by the residues of its past career, and by its own energies and equipment.

A function always shows an area of clarity and coherence. When you look at the pine tree yonder in the yard, one part of the visual pattern is more coherent and you reach a fuller apprehension of that tree and of the bushes round about and

the red barn beyond than you do of the crackle of the fire behind you and of the faint gnawings of hunger. One part stands out and the other parts are blurry and dim. Often these differences are so great that the psychologist speaks of foreground and background. Adherents of the doctrine of *Gestalt* or configuration believe that, whenever we perceive, one part of the pattern becomes more than a clear mosaic; they believe that it becomes a distinctive whole which they call 'figure' and that the rest of the pattern is unfigured and chaotic 'ground.' In some instances of perceiving this kind of difference in the pattern is very striking, although these cases do not necessarily incline one to accept the doctrine that the term 'Gestalt' implies. In whatever way we describe these differences in pattern, which are obvious to all, the fact itself is of great psychological significance.

This fact, too, has led to a good deal of careful experimentation. In one form of the experiments, the observer is trained to note a single quality in the entire pattern, to consider it as apart from the objects which are being apprehended, and to report to the experimenter the degree of clarity of this isolated item. In this event, the fact is spoken of as 'attributive clearness.' So the observer may listen, with a certain preparation, to the fundamental tone in a musical note and report upon its isolated degree of clarity. Those who have been interested in this sort of description and have given their observers the appropriate training and instruction have found it feasible to distinguish in perceptive patterns as many as nine degrees of clearness, ranging between maximal clarity and maximal obscurity. In observing in this way they make a point of excluding all reference to the perceptive product, considering only the qualitative side of the fluent function.

For a long time psychologists working thus in the laboratory believed that these isolated qualities could continue to exist only for a few seconds, and then men spoke of 'a fixed

duration of attention'; but it turned out that the duration depends, as the range or functional limit depends, upon many conditions, and that it may last a short or a long time. In view of the vast number of claimants upon the functions, however, and in view of the difficulty of holding the organism so steady and unchanged that a single item in the pattern might continue, the rule is for patterns to undergo almost constant shifts both in detail and in general course.

You will readily guess (whether or not you have yourself studied in the laboratories of the psychologist) that besides these refined determinations of the clearness of isolated items there are many other experimental problems upon the limits and clarity within the patterned functions. Your guess will be entirely correct, so that when you come to know the wide variety of precise experiment in this subject you will discover that the laboratories have made notable advancement. Since (as we have observed) these attributes of any patterned function are ordained by a very large number of circumstances, present and past, one of the main objects of experimentation in this field has been the discovery of the many conditions under which limit and clarity are determined. A few of these conditions may be set down as intensity, place, kind, complexity, and duration of the stimulating agent, the general state of the organism, the task set, the instructions given, the history of the functions invoked, and the concurrent functional trends in readiness at the moment.

Dominance and search. It is altogether likely that you have commonly thought of attention less as related to pattern than to the forward-reaching and searching side of organic operation. There you have hit upon an important matter. We never can exhaust our present topic until we have looked also at that side of it. No adequate account of the general aspects of function can be given if we confine ourselves to mere local differences of clearness. In the functions considered at large,

the dynamic aspect of search is fundamental. But this aspect sends us just as directly to the body, as the responsible agent, as any other aspect does. At the first beginnings of psychological performance in the infant we find this quality of pushing-ahead and reaching-out in the form of primitive search. And while this thrust of search comes in time to be combined in the most intimate way with all the other functions, with the state of the organism, and with the task in hand, it has invariably to be taken into account in studies of limit, of clarity, and of dominance.

In fact, one of the most pressing problems of practical living consists in finding for ourselves and in impressing upon the young appropriate motives and means for driving ourselves forward to the most effective modes of accomplishment. We cultivate search, so to say, by providing the most effective instructions, by the setting of the proper task, by inculcating, through repetition, precept, rule, punishment, example, and custom, the means for urging the functions forward to their most effective conclusion. And this restless, prophetic, and prospective aspect of our psychological living is more prominent in those functions which are least patterned (as in thinking and in expert action) than it is in the highly articulated patterns of perception and memory. What you have commonly called 'paying attention to' is often a close integration of the active function of search with other functions in course.

The reference to search leads us to remark that while clarity refers to the patterned aspect of perceiving, remembering, and so on, dominance primarily refers to the unpatterned aspect. One determination dominates over others, searching succeeds in a given direction, and one rival lead in thinking controls the field and presses on to its favored outcome. It is a peculiarity of emotion that, although the occasion (dramatic scene and seizure) demands a determined progress, the determined progress is—at the moment—want-

ing. Thus it comes about that the 'scenic' side of emoving remains prominent (though the organism's flurried state usually makes the perceptive and inspective patterns unstable and fugitive), while the visceral and glandular involvement brings in the florid coloring that characterizes the (third) stage of 'attempts at solution.'

Four Typical Performances in Daily Life

At the opening of this chapter the author promised, when the functions should have been reviewed in general perspective, to examine their interrelations in certain gross occupations of the day. The preceding paragraphs have now prepared us for this task. The occupations selected are *conversing, arranging, exploring, and studying.* While these four will by no means exhaust the play of function during a day's course, they will be representative. A command of the descriptive material in all the earlier chapters should enable the careful reader to make a similar analysis, in psychological terms, for the various forms of work and play, for the settlement of perplexing problems, for literary and artistic production, and for many other affairs of everyday.

Conversing. Where the verbal engagement of two individuals is no more than a planless reference, back and forth, to the immediate surroundings, to crass opinion, to bodily state, and to the weather, with obvious regurgitations of the near-lying past ('That was a swell dinner,' 'I have just decided,' etc., 'I heard a good story yesterday,' and the like), but little more is involved than casual perceiving and remembering, together with inspective bits, all thrown into verbal form. When conversing is made an art, however,—as exemplified by Plato and Boccaccio—the main support is a topic held in common by the participants, variously illustrated, embellished, and stabilized (our Case B under *Comprehension*), and, finally, creatively remodeled and extended (Case C) by the

conjoint efforts of the individuals engaged. Conversation that is really productive depends less upon the re-introduction of such old products as opinion, belief, and dissent than upon the pooled comprehendings and elaborative thinkings of the members of the group. We should not omit the fact of the social organization of the conversing group; but that aspect must be deferred to studies in social psychology which are to explain the various forms of human congregate.

Arranging. This kind of performance has many varieties. The essence of it is the setting in order of objects, facts, beliefs, and theories under a definite task. In the child's planful arranging of his toys, we speak of 'mechanical construction'; in the furnishing of rooms and buildings, we speak of 'interior decoration'; in the large municipality we speak of city planning; in the natural sciences, of classification and taxonomic order; in history of fitting events into the flux of time. Everywhere arranging is *setting something in an orderly array.* Here the chief functions, which are combined and coalesced in every conceivable way, are perceiving, remembering, inspecting, imagining, and comprehending. Commonly also the framework or design which governs the arrangement is the product of thinking skilfully combined with the products of imagination. Examples are the rules of artistic decoration, the tables of phyla and chemical elements, and the doctrine of organic evolution.

Exploring. The most obvious form of exploration is geographical—the search for new lands. Here action (of the automatized kind), perceiving, and inspecting are the chief prerequisites. If we distinguish the explorer from the mere pathfinder, we must accord to the former a liberal use of imagination and of comprehension. But taken in a general way, exploring covers many human events of a more modest and private character than the polar expeditions of a Peary or a Byrd. We all seek out, reconnoiter, identify, and con-

solidate the new. That is exploring. Here primal search, supported by appetite and lust, is variously combined with inspecting, remembering, and understanding. The occasions for exploration include the looking for lost objects, lost memories, and lost references, the search for new living quarters and new mates, and the examination of proposed plans or of new books. It is of the nature of exploration that the task implies an advancement into 'new territory' of whatever sort. Where persistence is difficult the flagging organism is sustained by all manner of instructions—formal, self-referring, and occasional—and by appeals to duty, necessity, and anticipated satisfaction.

Studying. The common example is the student at school or in college, with book, instructor, or laboratory-desk before him. From the point of view of the ambitious instructor—not always shared by the student—the primary necessity is an appropriate task, to be realized by the student himself. Here the instructor is readily supported by the psychologist, who well knows that the processes of study especially call upon those psychological functions whose determinations are set by a problem. These functions are chiefly inspection, comprehension, and thinking, no one of which succeeds save under the formulation of an appropriate task. Should no more exacting functional aptitude than that of memorizing be required, experiment has shown that 'intent to learn' sets a determination even there, a determination which enhances the organic means used and leads to a larger and better organized output.

Since the most desirable end of studying is still under debate (some prescribing 'development,' some 'education,' some 'training,' others 'preparation for life,' and still others 'acquisition of knowledge'), the processes and procedures of studying may be determined only with difficulty, except by a definite doctrine of the proper ends of this exacting occupa-

tion. That the practical art of studying has not been neglected of late we may infer from the number of books on 'how to study' coming from the presses. Since the psychologist neither diagnosticates nor prescribes, one remark upon the aims of the present book, as it relates to studying, will suffice. It would appear that, in this complicated performance, there is a place for the exercise of *all of the psychological—and many of the physiological—functions*. Under any conception of the aims and ends of education, therefore, an art of study which commanded only the simpler forms of apprehension and action, neglecting the more highly determined forms of comprehension, emotion, and thinking, would be, to say the least, partial and inadequate.

But studying is a performance wider than the school-room and the laboratory. Though 'uneducated,' a man may yet be 'studious.' He is studious when he engages in new tasks with a proper command of the means and materials necessary for their solution. It follows that studying is a compounded function of many phases, which is essentially independent of teacher or educative institution, these being only means designed to guide the process in the untrained or incompetent and to provide the material means and the atmosphere for studious occupations. The trained student—of whatever age—guides and directs his own study by the government and control of all those functions necessary to its diligent pursuit and successful issue.

The Psychological Limits of the Organism

We have discussed the limits of clarity in the functional patterns. Now we have to ask a much more general question with regard to the extreme limit or extent of performance in the psychological functions at large. Every machine has its limitations beyond which it cannot go. We commonly rate a mechanism in terms of horse-power, miles traveled, books or

papers printed, acres harvested, pure metal recovered from ore, cubic earth excavated, and on and on with all the multitudinous means which man has devised for his service. And so with regard to the living organism. The limit is reckoned there in work done by the draft-horse or camel, milk-yield of the cow, food consumption, gaseous exchange, and the like. The simple method consists in driving the machine or organism to a maximal performance and then measuring and assessing the product.

Now since the psychological functions also turn out their products—knowledge, topics, resolves, plans, manipulations, fears, hopes, and objects apprehended—products which vary with the particular functions employed, their government, and the exact conditions of operation, we may ask here too what the extreme output is in a given case and then relate the amount of product to the operating conditions under which it was turned out.

When we review the number of operations, physiological and psychological, that man is capable of carrying through, we find the array impressive. On the physiological side, there are all those internal processes which subserve digestion, circulation, repair, and regulation, chemical and neural integration, cellular metabolism, and the like. To those we must add the mechanics of movement, the fitting in to outside energies, and the physico-chemical interchanges. The body is certainly resourceful on the physiological side; resourceful in modes of operation, in the use of its members, organs, hormones, and enzymes, and in supporting, by integrative activity, all these interdependent operations.

On the psychological side, too, the limits of function are high and varied. We have had occasion to remark that the wide variety springs far less from a great number of functional modes than from the many combinations of a few modes and from the varied tasks and instructions under which we per-

ceive, remember, understand, act, and so on, from moment to moment and from hour to hour.

Take the fifteen-minute call just now in my study. Before ever the caller had found a seat I had acted (to open the door), perceived (his appearance), inspected (his brilliant tartan neck-scarf), remembered (my own gay Christmas gift), understood (his inquiry about my health), acted (to indicate the cigarette box), remembered (that he did not smoke), emoved (at my untidy galoshes not yet put away), acted (to push them away), perceived (my visitor's well-polished shoes), and comprehended (the polite but superfluous inquiry whether I was busy). Thus, in general, was the quarter-hour occupied; the drift of the call, the occasion, the give-and-take of desultory conversation, the self-references, and the topics from the past week, constantly priming each of our organisms for the turns of psychological activity. If you were to add—from other occasions—the strain to excel, the pressure of repartee, the task of imaginative construction, the narrow limits of time, the stress of business, and the heat of sharp argument, you would realize that the organism was only lazily jogging on through the last call and is really capable upon occasion of still greater and more varied exercise of the same psychological sort.

Over and above this facility and nimbleness, we possess various resources for integrating our functions while we carry on a single occupation under a single prompting task. The reading of a novel will furnish an illustration. Here are involved action of an automatized kind (holding the book and turning the leaves), perceiving (the illustrations), understanding (the plot), imagining (the scenes and sounds), commenting (on the characters), thrilling (with the dramatic events), and thinking in critical fashion (of the virtues and shortcomings of the author). Those are all fair samples of the range and resource of our bodies as business, pleasure, and social occasion tempt us to be psychologically active. [78]

Some of the tasks where psychologists have sought to determine, in a quantitative way, range and resource are learning by heart, carrying out skilled movements on the typewriter at various levels of accomplishment, rising from awkward to finished action under practice, tending machines at a maximal tempo, solving puzzles, taking examinations, striking out a letter from a pied text, and submitting to 'intelligence tests.' When you take any one of these studies of range and of rate, you will see that (1) it sets a task, (2) it involves varied instructions of our three sorts (formal, occasion, and self), and (3) it calls upon our functional modes in various combinations and sequences. Where we more informally test our limits outside the laboratory there is less of the formal instruction and more use of the self-object in pressing the organism to the top-notch of performance in order to see how far we can go in business, argument, or sport, when we really try.

It would seem to be much simpler to test a single function under a single instruction instead of driving ahead at a complicated task by using any resource that happened to be at hand. But this usually involves the laboratory, experiment, and carefully trained observers, who recognize 'pure' functions when they use them. Such an experiment might determine the greatest number of small objects or letters that can be perceived simultaneously; or the delicacy of distinguishing (by inspection) linear distances, tonal differences, or degrees of cold upon the skin, or the maximal rate of moving the finger at a signal (action), the number of topics understood in unit time, and so on and on.

Just as obvious as the fact of limit is its variability. One day the limit is high, another day low. An insoluble task yields to practice or melts away after a good night's sleep; or it may only need a greater urge, a stronger resolve, or a new method of solution. So versatile is man and so complex are the condi-

tions of his performance that we cannot hope to determine anywhere in human accomplishment such fixed constants as the breaking point of a standardized steel-bar or the melting point of a chemically pure substance at a given pressure. Nevertheless, we can discover and measure the range of variability in a specific performance of the organism, as well as in the differences in performance from individual to individual.

A great many of the epithets by means of which we seek to characterize our fellows prove upon scrutiny to indicate notable differences of accomplishment. For social and human purposes we tend to exaggerate these differences, making them appear as qualitative peculiarities. Thus we say of our neighbors or of our children that *A* is industrious and *B* lazy, that *C* is bright and *D* is dull, *E* irascible and *F* of an equable disposition. At the same time, we know, however, that human beings are all modeled after the same pattern, all possessed of the same ultimate qualities, and all capable to some extent of the same fundamental functions. The final differences are presumably differences of degree. At least so far as we can describe human beings in quantitative and numerical terms, we may reasonably hope to be able to place them upon the same scales and to measure them by common means. Whether any such quantitative delineation is at present feasible or, if feasible, then adequate to the differences of men, are still unsettled questions.

The Dependence of Limit upon Motivation

The notable rises and declines of function and accomplishment lead us to comment upon the motive powers of the organism. Whence the energy? Whence the incentive for performance? and Why the frequent shift in limit?

Not only do individuals differ so markedly in their psychological accomplishment as to make these variations the basis for such distinguishing traits as active, efficient, sluggish, driv-

ing, slack, and slow; one and the same organism has good days and poor days, dragging tasks and alert execution, absorption at white heat and dull hours of inefficiency, favorite occupations which run fluent without effort, and inaptitudes which bring him out at the tail of the race.

In an essay upon *The Energies of Men,* William James declared that "the human individual lives usually far within his limits...He energizes below his maximum and he behaves below his optimum...Of course there are limits: the trees don't grow into the sky. But the plain fact remains that men the world over possess amounts of resource which only very exceptional individuals push to their extremes of use... We ought somehow to get a topographic survey made of the limits of human power in every conceivable direction, something like an ophthalmologist's chart of the limits of the human field of vision." [79]

The initiated reader of James will not miss the ethical implication that man possesses a 'capacity' in the sense of ultimate 'reach' toward which his 'grasp' should strain. This is, of course, not our factual limit of performance under prescribed conditions of practice, age, education, instruction, etc.

So important for living has been this variation in range, facility, and limit of function that reflective men in all ages have sought both its causes and its control. History abounds in theories of human motivation and of its variations among men. The mere title of these thories is significant; pleasure and pain, strong and weak wills, inspiration, instinctive drives, education, bodily energies, *libido, élan vital,* psychic energy, the springs of character, the force of sentiments, the ego, the unconscious conflict, and many others. Among the psychologies there has seldom been a dearth of 'dynamic' systems, which have made some form of driving force basal to mind and explanatory of man's activities. Typical psychologists of the dynamic order are Herbart, Schneider, Fouillée, Janet,

Bergson, James, Freud, Jung, Münsterberg, Woodworth, and McDougall.

Of course, after our elimination of 'mind' as an inner part of man and 'mind' as a form of energy or spiritual force, we cannot accept any of these 'dynamical' notions, save as they translate their 'powers' into terms of (1) bodily resource of function, (2) actual governing factors, and (3) the repercussion of the psychological products upon the operation in course. Man lives, acts, and accomplishes in a psychological world. If we leave this world (the issue of former functions) out of account, we leave out one of the principal actors in the play. Then we are left the choice of packing all causal agents into a magical mind or soul, of accounting for our performance by instincts or a mythical heredity, or, finally, of assuming an all-powerful 'stimulus' which drives the passive organism to 'response.' [80]

Especially with regard to the driving, determining, and selective conditions of a given functional employment must be reckoned the cumulative force of the past, both as this moulds the body to present activity and as it gradually unrolls a biographical career, tempering anew every year and every day the psychological activities. With respect to the determining force of the psychological products must be reckoned tribal, national, and family manner and mode, the social prescriptions of people and class upon the preferred manner of individual activity in the home, in school, in the neighborhood, and in the state, as this manner touches upon, by way of rule and commandment, the ideals of growing up, of learning, of working, and of taking responsibility. To these social products, we must also especially add that powerful *self-object* which we gradually create and which as constantly determines and motivates our behavior as it is constantly remoulded while life lasts and experience instructs.

All these rules, maxims, canons, and other social prescrip-

tions and every new phase of this intimate self-object charge and motivate the individual quite as truly as, and more often than, do the 'drives' of sex, hunger, and thirst. It follows that any doctrine of motivation which leaves out of account these socialized products of the psychological operations substitutes for the actual life of man an unreal and abstract manikin that only behaves because it is actuated by the strings of 'stimulus' and urged by the blind and unruly stirrings of viscus, gland, and muscle.

Since the long stream of functioning is fed from so many springs, we can scarcely expect to throw all motives into any single class of innate or acquired powers; but inasmuch as we know that the *present occasion, the bodily conditions of functioning, and the products of function* conceal all of these springs, we may direct our inquiry, in any individual case of functional range, variation or limit, in a definite direction and hope to recover many—if not all—of the chief motivating factors.

The Measurement of Function

The phrase 'limit of function' suggests measurement. It suggests varying amounts of functional performance which might conceivably be laid off along a graduated scale with *zero* written at one end and *maximum* written at the other. Immediately we think of our spatial scales and rulers divided up into inches or millimeters. These linear units, laid along or superposed upon unknown extents, give us our simpler and more familiar examples of measurement. There the process consists in finding how many times the unit is contained in the total extent. The procedure implies that the extent to be measured can be divided up into (or, at the least, considered as made up of) a number of homogeneous and equal parts. Superficial and solid measures and measures of liquid contents (*e.g.*, the liter or gallon), as well as such weighing

measures as are determined by balances and scales, are essentially of the same order. At times it is impossible or impracticable directly to take a unit-quantity of the thing to be measured and to lay it along the whole extent. Then it is common to use a substitutive unit. Thus we measure time in spatial units (clock-face or stellar position) or in changes of light (day and night) or in alterations of temperature and of season (summer, autumn, the year). Although we then *report the result* in time-units (second, minute, year, century), we actually *estimate* by means of the spatial, photic, or thermal substitute. [81]

Two large groups of method have been proposed for the quantitative study of psychological performance. One group contains the *psychophysical methods* (to be referred to as the *P*-methods) and the other the *methods of test* (the *T*-methods). The two groups have the same mathematical basis; and it would be more logical as well as more convenient if we could treat them together. They have had different histories, however, coming into psychology from different directions and with different contexts; so it is necessary to regard them, at least for the sake of exposition, as different kinds of procedure. We may hope, however, that whatever is of use to psychology itself—not to anthropology, to education, or to medicine—will presently be collected from both and consolidated under one single form.

The *P*-methods were named from the fact that they undertook to express a simple uniformity between sensory magnitudes and those physical agents (stimuli) which produce them. Hence the term 'psychophysical.' Instances of the application of the *P*-methods are the measured determination of a sound just strong enough to produce a tone or of a solution of common salt which just gives rise to a salty taste. The measurement may pertain also to colored lights which are just distinguishable or to the least discriminable pressures

upon the skin. The quantity measured is in terms of energy applied to the receptor, but this measurement is always referred to some aspect or detail of a psychological function.

The *T*-methods, on the other hand, were proposed to 'try' or to 'test' the extreme capabilities of the mind or of behavior, as the engineer tests the limits of performance of a machine or the carrying load of a bridge. When they are called 'mental tests' they imply that the mind can be put to work and then measured in terms of its accomplishment or output. The *P*-methods came from a separate study called *psychophysics,* while the *T*-methods came in part from that branch of the quantitative study of mankind known as *anthropometry,* and in part from *biometrics* (a fairly recent department of general biology and genetics). Gradually they have receded from their biometrical origin. Testing has for some time been encouraged by education and by other technological subjects which are interested in assessing human abilities and human resources on the side of output and efficiency.

So far as the general assumptions of these two types of method are concerned, they have much in common. Both are statistical; that is to say, they assume large numbers of homogeneous, or at least similar, phenomena, which can be grouped together and treated in the mass. They assume that the individuals in a given mass are so distributed, in respect to a given characteristic or trait, that the type of distribution can be quantitatively expressed or measured. These statistical methods are widely used in the study of population, of birth and death rates, in financial problems, and elsewhere. They consider the individual phenomenon or person only as a member or a representative of, or a unit in, a large group. [82]

The psychophysical methods. The *P*-methods have been most frequently used to determine the limits under definitely prescribed conditions of perceptive and inspective functions. Many instances are at hand of precise measurement of the

discrimination of color, light, tones, pressures, and other qualities which enter into the patterns of these functions. Here it is possible to hold constant the occasion, including a constant series of photic, acoustical, or mechanical energies, while the stimulus impresses the organism over and over again for hundreds or thousands of times, to hold constant a fixed formal instruction (*e.g.*, "report which of the lights is more intense"), to rule out all shifts in the task, and to control self-instruction ("take the task in a detached manner and always in the same objective way"), and to accumulate a great number of results taken under the same conditions, save as the organism itself changes from moment to moment, introducing accidental deviations which may be eliminated or allowed for in the statistical treatment. Thus function, product, bodily conditions, and government are all held in strict control by the *P*-methods.

One of the main results from these methods thus applied to the discovery of small differences is that change in the strength or intensity of the individual quality in a perceptive pattern is dependent upon the *relative* difference in the stimulating energies. Thus if 100 and 110 photic units lead to a certain unlikeness in the light intensities, then 200 and 220 photic units will lead to the same degree of unlikeness. The ratios $\frac{100}{110}$ and $\frac{200}{220}$ are the same (*i.e.*, 10:11). This discovery that pattern-strength increases in a simple arithmetical way while the stimulus increases in a geometrical proportion (*i.e.*, with a *relative* constancy) has been formulated in Weber's Law, which was stated (1834) by its discoverer E. H. Weber, (1795-1873) in the following way. "In comparing objects and observing the distinction between them, we perceive not the difference between the objects, but the ratio of this difference to the magnitude of the objects compared." So far as the 'law' holds,—*i.e.*, generally over the middle region of the intensive scale—it means that to acquire the smallest intensive increase it is always necessary to add a constant fraction of

the stimulus: $\frac{1}{8}$, $\frac{1}{5}$, $\frac{1}{40}$, $\frac{1}{100}$, etc., according to the modality or the sense-series (brightness, noise, tone, etc.).

Besides the determination of the limit in these simple functions the *P*-methods have also been widely used in the study of illusory perceivings, in determining speed and accuracy of movement in the simple and the automatized actions, in memorizing, in studies of clarity and dominance, and in many other problems which demand a long series of comparable determinations taken under a fixed task and with the organic conditions held as constant as the conditions of life will permit. The methods provide for their results a well-founded statistical treatment which gives measures of the limit sought, of the precision of the function which is operative, and of the range of its variability. [83]

It is clear that precise and delicate methods of this sort belong to the laboratory and are to be used only by highly trained experimenters and observers. They are no more applicable to the gross conditions of life than the histologist's methods of preserving and examining the fine tissues of the body are, or the physicist's determinations of the exact rate of light-transmission. Where the psychologist or the technician does seek to discover the top limit of performance in the school room, in business, or in the private affairs of life, he applies the much grosser methods of the 'test.' Those methods we must now examine.

The methods of test. The *T*-methods bear an intimate relation to the school examination commonly used to test the student's knowledge. Like the examination, the test is meant to be diagnostic in the sense that it is designed to furnish information within a field of knowledge which extends beyond the actual items composing the test. In the 'vocabulary test,' *e.g.,* a few words chosen from a general dictionary are placed before the child who is instructed to define them. The definitions given for, say, one hundred words are used to denote the

child's grasp and understanding of his mother tongue taken at large. In the school examination, likewise, a few samples from an entire term's tuition in a subject are commonly taken to represent the youngster's profit from the entire course. This method of sampling is also widely used in buying and selling, in testing the structural properties of steel, wood, and other building-materials, and, in a grosser form, in a man's determination of the personal and moral qualities of his fellows. The boy who resists the temptation to pilfer when he is not watched is favorably considered for a position in the town bank or freight office, and the man who keeps his head at a fire may be regarded as a good person to direct traffic at busy corners or to despatch trains.

When testing came to be a more professional method than in the school examination, men used materials which were new to the person tested, new in the sense that they had not been specifically taught. Thus Alfred Binet, called on to weed defectives out of French schools, asked a suspected child to give his family name, to repeat a sentence, to name common objects, to copy, to describe a picture, to count money, to define, to solve puzzles, and so on. From his preliminary results Binet found what normal children could do at 3, 4, 5 . . . to 15 years. When a ten-year-old just came up to the average accomplishment of the normal ten-year-olds he was said to have a ten-year intelligence, but if he came up to the eight-year or the twelve-year average he was rated as having an eight-year or a twelve-year intelligence or to stand at a *mental age* of eight or twelve years.

William Stern later proposed the expression, *mental age* ÷ *chronological age* = *intelligence quotient* (IQ). The 10-year child who passed the normal 10-year test would have an IQ = 1.00 ($\frac{10}{10}$); another of the same age who could do only the 7-year test, an IQ of .70 ($\frac{7}{10}$); while the 10-year old who passed the 12-year test would attain an IQ of 1.20 ($\frac{12}{10}$). In

practice these numbers are usually multiplied by 100 and thus become 100, 70, and 120. This use of the ratio *mental age: chronological age* assumes both that the mental age (as measured by the tests) derives its chief significance from its relation to chronological age, and also that the whole range of IQ's is measured upon the same scale and in terms of a common unit. [84]

Many definitions have been offered for 'intelligence' and have been hotly debated. The tendency of late, however,

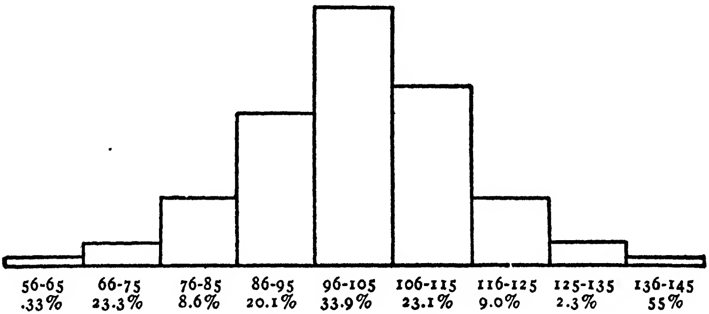


FIG. 49.—DISTRIBUTION OF IQ'S THROUGHOUT THE CHRONOLOGICAL AGES 5-14 YEARS (905 UNSELECTED CHILDREN)

[From L. M. Terman, *The Measurement of Intelligence* (Houghton Mifflin Company, New York, 1916)]

among those who make the tests has been to take the word to mean *whatever acceptable 'tests of intelligence' measure,* and to interpret their test-results appropriately in school, in the clinic, in selecting individuals for special tasks, and so on.

The outcome of testing is subjected to much the same statistical treatment as in the *P*-methods. This treatment rests—as we have seen—upon the same mathematical assumptions regarding the pattern of distribution of comparable numerical results collected in large numbers. The statistical treatment

bears both upon the entire group of results and upon the position of the individual measure within the group. Instead of saying that a given person tested is good, poor, or deficient; slow or quick; dull or bright, as regards any characteristic or aptitude, it is possible to say (1) that he stands, in some specific accomplishment, 3, 5, or 12 points above or below the average, and (2) that his deviation from the average bears a certain relation to the probable error or the standard deviation for the entire group. In a concrete case, these statistical refinements may mean that an individual *A* has correctly spelled, in a contest among 100 persons, 2, 7, or 14 more words than the average, and in addition that he exceeded the average accomplishment to a degree that was attained by only 10, 6, or 2 of the 100 contestants. The individual accomplishment thus takes on an added significance when it is related to the mass performance of many comparable individuals.

The measures representative of the individual have been more used in the test than in the *P*-methods. In the former, the demands of practice—particularly of education and of the study of defect—make it important that the individual should be given a *rating or status*. The chief representative values sought in the statistical treatment are measures of *central tendency* (the average, the median, the mode), *i.e.*, the drift of the entire mass toward a central value, and measures of *variability, dispersion or scatter* (average deviation, standard deviation, probable error). The ordinary bell curves represent the same symmetrical type of distribution about a central measure (the mean); but they show various degrees of variability or scatter.

Besides tests of intelligence, tests of character, will, and temperament, industrial and vocational fitness, ability in school and collegiate subjects, in music, drawing, and writing, and many other studies and occupations have been invented. These are generally devised in order to discover individual and group limits. Some are alleged to measure innate abilities and

others acquisition in and out of school. Some of them are found to be diagnostic of high, mediocre, or low ability in certain directions, or of disorder and maladjustment. Some are said to be prognostic, indicating definite functional limitations or limitations in government which are likely to fit or to unfit the individual for specific occupations or, more generally, for healthy and effective life in society.

In order to determine the bearing of the test-results upon each other and upon outside matters, methods of correlation have been worked out and widely applied. These methods seek to express, with a high degree of probability, a kind of relationship among individuals which cannot be directly measured. Thus a certain moderate degree of association between stature and weight obtains, due to uniformities of growth. It is not possible, to be sure, to predict that a given man 5 feet 11 inches in height will weigh exactly 172 pounds; but it may be possible to express by such a decimal number as $r = 0.66$ (coefficient of correlation) the fact that the conditions which determine stature also have, to a considerable extent, an influence upon weight; and so to fix the probable relationship between the two characteristics. In this case (to explain more specifically) the decimal 0.66 indicates the probability that our man of 5 feet 11 inches who is above the average *height* will be a corresponding amount above the average of his class in *weight*. If it is proper to speak of this value r as a 'measure,' we shall have to say, not that it measures the individual man, but that it measures the probability that, in his case, the concomitant variation of height and weight will be exemplified. In no case should the coefficient be taken to be a percentage or to indicate the number of chances in a hundred. It indicates only a certain statistical probability, a probability which always remains to be interpreted into more concrete terms of relationship as between the individual and the group. [85]

Psychology and Life

We end as we began. Psychology observes and reports upon activities of the living creature. The fundamental activities it shares with physiology, the two subjects making a natural and sensible division of the functions which they find in process in the active organism. In distinction from many other interests of man in his own life and in the lives of other beings, psychology always maintains the attitude of knowing, avoiding the rival attitudes of appreciation and use. Since it stands among the natural sciences, psychology eschews mental forces and powers, which belong to the realm of magic and of private possession.

In our treatment it has been found unnecessary to assume any kind of 'mental' existence. On the contrary, the book regards the living body as the common structural basis for all the organic activities, both physiological and psychological. What is psychological then, is, first, a type of performance and accomplishment, and, secondly, the control or government of the performance which determines at any given time and upon any given occasion the functions which are to be active as well as the direction and outcome of their activity.

The entire volume has been devoted to a descriptive account of these functions, the bodily organs and processes which underlie them, and the means and manner of their government. The specific involvement of function and government in the developing individual and in the evolutional series of human and non-human forms (Genetic Psychology), in a psychological comparison of individuals, ages, races and genera (Comparative Psychology), in the social and congregate activities of men (Social Psychology), and in disease and disorder (Psychology of Disorders) is all left for another occasion. It will appear, however, that in all these special divisions of psychology the concepts of function and government are as

appropriate and as adequate as in our present fundamental treatment of the normal adult man.

Everyday living is an art; but it is an art which requires in thoughtful men and women an orderly understanding of those functional and governmental facts which are to be found in the sciences of life. Here biology and psychology are prepared to make similar and correlative contributions.

SUPPLEMENT

SUPPLEMENT TO CHAPTER I

[1] These common sources of confusion may be further commented upon.

Psychology and magic. It may seem strange to you that men have been slow in acquiring a straightforward and reliable account of the psychologist's world. The chief reason is not far to seek. The age of scientific description was preceded by unnumbered centuries of magic. Before men considered natural causes and formulated sober natural laws, they were governed by ritual and by a belief in spirits, demigods and divinities. The great men of those earlier times were the priests and the magicians. Instead of orderliness in nature men found caprice, cunning, and malice. Nature was more to be appeased than reasonably understood. Gradually, in spite of magical traditions, came hints of a natural order. The storm arises—as man at last discovered—not from angry gods but from meteorological conditions, pestilence from the disregard of hygiene and not from the maledictions of an avenging spirit.

In the physical realm our own generation stands so far removed from the first conquests of science that magic there seems foreign to the present modes of thinking. To realize its ancient spell we have to search out such persistent superstitions as the bad luck of Friday, the omens of the new moon, the sinister import of the looking glass at funerals, and a vestige of the priesthood among family doctors.

Concerning the magic of an active and controlling mind or spirit the whole case stands otherwise. There the human race at large still lingers in the twilight of credulity and superstition. There the occult is still respectable. Men who would scorn an invocation of spirits to account for the lightning and the volcano find nothing incongruous in an appeal to mystical agencies to

explain the coincidental thoughts and longings of separated friends; and they accept, without understanding or criticizing them, such explanatory terms as 'telepathy' and 'hypnotic power.'

Among the unenlightened, mind is a mysterious agent which sweeps through space without a vehicle, defies time and the laws of nature, and controls destiny. But many persons of general intelligence, as well, entertain a pre-scientific notion of psychological forces and powers. Several hundred university students who were recently making their first approach to psychology were asked to set down in simple language their conception of such agencies. Three-fourths of the whole number appealed to declared that they believed mind to be some sort of power, faculty, force, or directing influence which controls the lives of men. Almost half of them regarded the mind as material, a substance to be identified either with the brain and nervous system or with a peculiar and subtle inhabitant of the body; while one in five identified it with the 'soul,' 'personality,' or some other immaterial substance. Not a few were more vague, looking upon it as a mere receptacle or as an unknown something which was susceptible of training and development. Shreds of discarded philosophies, traditions of magical belief, expressions of a universal longing for power and influence, and unsorted scraps of physics and physiology!

Psychology and traditions of learning. Psychology has received a double heritage; the traditions of philosophy and the traditions of the sciences of life. Much specialized knowledge goes back to philosophy, as it also goes back ultimately to magic. As soon as men began to elude the spell of the occult and while they were painfully trying to puzzle out nature's actual modes of operation, they turned aside to construct a reasonable and consistent account of the whole realm of existence. "What does life mean?" they asked. "What is the relation of man to nature?" "What are the final constitutents of all substance?" Some of the early attempts to solve these riddles of the universe are to be found in the Greek cosmogonies and in the Vedantic and other classical writings of the Far East. They have exerted a profound influence upon man, who is always reverting to these persistent and really insoluble problems. Even physics and astronomy, the oldest of

the empirical sciences of nature, required hundreds of years to shake themselves free from the entanglements of philosophy as well as from the spell of magic and superstition. Our textbooks in these subjects are now chiefly filled with sober facts and empirical principles; although some physical theorists persist in metaphysical romancing.

Psychology has not come off so easily. The alleged agencies and powers seem to be intimately related to knowledge, and knowledge has belonged in a peculiar way to the metaphysician. Moreover, the intimate relations of things psychological to the personal and emotional sides of life have always tempted men to speculate. So mind has long stood under the shadow of philosophy as it has stood under the spell of credulity. Conjectures upon its creative and legislative powers have always stood in the way of a straightforward comprehension of the psychological facts. But conjectures and speculations must be avoided by us at the outset; for they spring just as inevitably as does our magical interest from another attitude than that of observation and description.

The tradition from the sciences of life is of a somewhat different order. The later generations of the nineteenth century have been called *biological* generations because of their extraordinary contributions to the biological sciences. The formulation of principles of organic evolution, the establishment of physiology, and the application of chemistry to the facts of life are all landmarks. Instead of the old anatomy and medicine which harked back to the Greek physicians, there are now to be distinguished a whole series of disciplines, historical, morphological, physiological, biophysical, ecological, and pathological. Life in all of its phases, including the congregate life of men and of animals, has been surveyed. The study of it has thus gained a marvelous prestige in the eyes of men; and incidentally it has in various ways encroached upon the domain of psychology.

Some biologists have thought of mind as a secretion of the brain, or as a kind of inevitable froth which appears upon the eddying currents of life; others of them have looked upon it as a delicate regulator of the body; others again as an instrument of adjustment between the organism and its surroundings; and still

others as a reservoir of energy which can be drawn upon for the welfare of the organism in health and in disease. These neighborly interests have not failed to influence psychology. Indeed, certain psychologists, whose main affiliations are biological, have been frank to say that, for them, psychology was just a branch of biology. This biological view is not the view which will be sustained in these pages. We shall, on the contrary, independently regard the primary facts of psychology, referring them neither to philosophy nor to the sciences of the body. This resolve may seem to restrict our survey to a small group of materials. It does not; as we shall presently see. Instead it will leave us free to consider practically all of the problems which have grown up from many sources and under many influences in empirical psychology, but to consider them from a single point of view, or, at the least, to place upon them a single kind of emphasis.

The difficulties from language. Language has a magic of its own. When once we have discovered the name for an unfamiliar object we easily persuade ourselves that we then know the object itself. A vague halo of familiarity surrounding a name seems to acquaint us with the qualities of the thing named. At times we realize our ignorance only when we are asked to define or to describe, for we often claim knowledge where we cannot define. To many primitive folk the name is part and parcel of the thing or person; and when an individual gives his name he not only bestows a part of himself but he also makes it possible for the person informed to do him injury. Thus natives of the Torres Straits settlements refused to tell Dr. Haddon their names; "the idea being that by telling their own name to a stranger they were voluntarily putting themselves into the power of that stranger." Since words have so powerfully impressed the race and since they still play a large part in our understanding, it is not strange that we often accept the symbol for the thing signified. To the word 'mind,' for example, men often seem to themselves to attach concrete meanings when their actual knowledge is extremely hazy and vague. Thus 'mind' is popularly supposed to 'work' or to 'refuse to work'; to be 'concentrated' or 'distracted.' It is

alluded to as 'alert,' 'agile,' 'quick,' 'energetic,' or 'sluggish.' Again it is said to be 'lost,' 'unbalanced,' or 'disordered.' Men also regard it as a heritable thing, bearing family resemblance to ancestral minds, but capable of making its own way and of surmounting difficulties. Moreover, 'mind' is commonly assumed to be useful, in the forms of intelligence and will, for the solution of problems, the acquisition of learning, and the conquest of nature. It thinks, imagines, remembers, chooses, resolves; and it is moved by sadness and pity, distressed by grief, and disturbed by uncertainty and doubt. A mind which works, which fails us, which is concentrated or distraught, is evidently an agent with powers. The epithets agility, quickness, sluggishness, etc., specify certain particular forms of power. We might call them the *gymnastic* qualities of mind. The possibility of loss, disorder, and unbalance suggests that these qualities may suffer eclipse or derangement; and the emotional disturbances of pity, grief, and fear imply similar, if slighter, aberrations. In the same sense, a 'heritable' mind would appear to be one which is racially equipped to perform duties for the individual, and 'intelligence' and 'will' are other expressions of a power supporting the organism in various exigencies of life. In the everyday and gross uses, then, the term 'mind' tends to refer us away from the concrete facts of living, and also away from the realm of psychology, to an unknown cause, to a vast empty circle of whose properties we know little more than a vague understanding of the qualifying words employed.

We have, therefore, to turn to the psychologist. We go to him for a workable conception of the psychological factors in living just as we go to the physicist and the chemist to learn about the atomic constitution of matter or to the biological sciences for reliable information about the structure and the history of living creatures. And when our common, rough-and-ready knowledge fails us and we resort to the sciences we must expect a certain amount of sophistication. The world of the chemist is not the world of the cook. The chemist looks upon the universe as vast systems of moving electrons. The atom itself is, for him, an ordered system of electrical charges, some of which are traveling

at prodigious velocities. No such object appears within our ordinary visual range. The world of homely and familiar objects about us *does not look or sound or feel* as if it were so made. In a similar way, the student of life transforms familiar bodies into vast colonies of minute cells, each one of which is in turn exceedingly complex in structure and in its operations. Physics, also, transmutes our familiar world of light, heat, sound, and color into a lightless, heatless, soundless universe of vibrating and oscillating changes. Thus each of the sciences, setting out from the phenomenal world of our casual inspection, creates its own interpretation of existence—an interpretation which is consonant with its own point of view and its peculiar problems. In this sense all accurate and technical description of every kind is sophisticated.

A difficulty which especially afflicts our own generation is the easy, unconsidered, and unscientific way in which it is the fashion to use the terms 'psychology' and 'psychological.' Almost everything which makes reference to the more intimate aspects of the life of man is now labeled psychological. We hear of psychological novels, psychological plays, psychological sermons; of psychological healing and psychological methods in business. Golf is said to have its psychology, as well as chess and bridge, dress and education. The 'psychology of' is one of those interesting phrases which mysteriously appear without warning, run glibly off the tongue, fill the popular magazines, and temporarily excite the public imagination. When such a phrase attaches itself to strong emotional interests, as to religion, health, sex, sport, recreation, and the fine arts, and when further it acquires, as 'psychology' has acquired, the profound sanctions of science, medicine, and literature, its influence is likely to be deep and to pass beyond its own intrinsic merits. It is quite true that the advances of psychology have thrown light upon many matters hitherto obscure; but very often the phrase, 'the psychology of so-and-so,' indicates only a popular and worthless description couched in high-sounding, but ill-chosen, terms. Against these extravagances the novice must be on his guard until he is able to distinguish the genuine from the spurious. Once he is persuaded that whatsoever touches human

nature is *psychological,* he is hopelessly lost and confused. There will then be for him no place to begin and no place to end. It would be as if zoölogy were extended to cover everything which concerns animal life. That would include the raising of cattle and sheep, the processes of the slaughter-house, the care of pets and of domestic animals, hunting and fishing, and so on indefinitely. No; it is only quite special ways of regarding life, only quite definite means for the observation of living things, which fall to the student of zoölogy. And psychology is just as clearly and closely limited by special ways and special means. To be sure, there are psychological avenues of approach to human nature; but these approaches always imply a particular kind of intellectual interest and the impress of a particular envisagement and point of view.

Mind regarded as a personal possession. Finally we may direct our steps toward a coherent and sound psychology only when we have come to realize that our naïve and pre-scientific view has invariably been a personal and private view. Life is full of struggle and conflict; and just as man seeks control and contentment by annihilating space, by expanding or contracting time as his need suggests, and by conquering natural forces, so does he seek to match his wits against his fellow's, to gain and to use knowledge for personal ends, to interfere in his own destiny, and to influence his family, his friends, and his fellow men at large. The chief instrument and resource, in these latter endeavors, is—as he thinks—his mind. It is no wonder, then, that he holds it to be his closest ally, the "guest and companion of the body," as Hadrian sang, and that he considers it in a highly emotional and wholly biased manner. But to value, to cherish, or to use is not to know!

[2] Once we drop the old notion of mental constituents and existences and consider only psychological functions—their kinds, conditions, genesis, growth, and accomplishments—we shall find the subject easier than we anticipate and we shall in addition find ourselves delivered from a host of perplexing and vexing problems about how mind and body exist together, how they influence one another, or dwell in peace or conflict within the

same living being. At the same time, we must not avoid the plain facts of our daily existence and experience by pretending, as some behaviorists do, that the only thing left for the psychologist, once he discards the category of the conscious, is to observe the movements of the body and to interpret them by some such biological doctrine as survival, adaptation, or adjustment. It is one thing to discover that a belief in mental substances is not practically useful in psychology and quite another to shut our eyes and ears to all the plain and indisputable facts of our individual and social living.

[3] The word function itself is so hackneyed and so ambiguous as to embarrass any attempt at definition. We may come to terms with it, however, by observing that the word may be taken to mean either *a mode of operation* or *a kind of accomplishment.* Consider these meanings in turn. To say that a house may be built by flowing liquid concrete into a sustaining framework or that it may be built by laying up walls of brick in mortar is to indicate two different *modes* or *ways-in-which* a thing is done. That would represent 'function' in the first sense. There different agencies are used toward the same end, the building of the house. On the other hand, to observe that firearms are used for the procuring of food and for personal defense against assault is to point to a functional difference of the second sort. There an agency is employed for unlike ends. So we may say that the organism works in two *modally different ways* in recalling an old solution of a problem and in actually thinking the problem through, in acting from choice, and in trusting to impulse. There we consider different functions as different ways-in-which something is done. But when we speak of different ends, as of escaping danger or of adjusting oneself to society or of creating a new code of morals, then function is of the second or accomplishing kind.

Now to depict a function or operation in its own terms is always more significant than to substitute for it its end. To say that printing is that process which turns out books and newspapers is not descriptive. It gives no intelligible idea as to how the printing press works. This is the easier way. Means and modes

are often fugitive or complicated; whereas products are likely to be permanently at hand for deliberate scrutiny. That is probably the reason why men are prone to refer vaguely to forces or powers which are supposed to be responsible for the production of some observed result. They are like the physician in Molière's play who gravely explained that sleep is brought about by the action of a *dormative principle* within the body. To say that one instinct tends to preserve the race and another the individual tells us nothing about the instincts themselves. It does not even demonstrate the existence of them. To say that one tribe so conducted itself as to survive while a neighboring tribe became extinct gives us no information upon their modes of living. As a matter of fact, we shall find that the functions which we are now considering have been regarded in both ways, as modes and as accomplishments; but more frequently in the second. We shall prefer the first way, however, and we shall give notice of any departure from this meaning of the troublesome term.

[4] In further support of the remark that the physiologist is not at home among the facts of psychological functioning, you will find, if you read through all the biological subjects—anatomy, physiology, embryology, ecology, and the rest—that you do not come upon any adequate treatment of the fact that man sees and hears objects, remembers his past, anticipates, plans, resolves, thinks, understands, and appreciates. These central and important operations are left to the psychologist. To be sure, certain of the biological sciences throw much light upon them, describing eye and ear, muscle, nerve, brain, and other bodily resources which are indispensable to them; but the nature, forms, history, and limits of these operations remain for psychology.

It appears, then, that we may usefully distinguish two coördinate groups of the sciences of life; *biology* (taken in the wide sense) and *psychology*. All the subjects just now named (anatomy, physiology, etc.) then fall under the biological group, while our own present concern is to be with the psychological group. Since psychology deals primarily with certain definite and definable functions of the living organism, we shall agree that it is one of the *sciences of life* but not one of the *biological sciences*. The most

intimate relations obtain among all of the life-sciences—just as they also obtain among the physical and chemical sciences—; but psychology would appear to have enough tasks and methods which are peculiarly its own to set it apart as a separate subject for study and for research.

There is, however, one striking and very important difference observable as between psychology and the biological group. It is this. Psychology requires for itself no anatomical or structural division. There is only one organism in the sense of *existing structures*. This is the body, which operates and performs in a great variety of ways.

[5] It is worth noting that the psychological functions of the organism are always primary in the sense that we know no anatomy, no physiology, no morphology, until we have exercised our functions of perceiving, remembering, understanding, and the like. More than this, all knowledge, all taste and valuation, and most forms of behavior, rest upon, and are to be understood only by, the underlying psychological operations of the living being which produce and sustain them. But in spite of this functional primacy, we must repeat that all structural matters of the organism fall to the biological group. These subjects have often been set parallel to psychology, on the assumption that the organism includes some kind of mental or conscious stuff which exists alongside of the bodily stuff. To this parallelism we need not agree, in spite of the great age and respectability of the assumption that man is thus compounded of two irreducible kinds of constituent material, bodily and mental. The assumption has been useful to man in many contexts. But there seems to be no longer any reason for retaining it in our scientific contexts. When any one of the sciences of life desires information about the structural side of the organism it must go to anatomy and morphology. Psychology itself needs no structural side or counterpart which could be called 'mental' or 'conscious.'

[6] *The functional modes and varieties.* We shall not really know the organism in a psychological way until we study it while it is seeing objects, listening to the roar of traffic, apprehending the

power of the thundering locomotive, and observing the make-up of rocks or the flavor of well-cooked food; while it is criticizing fellow creatures, feeling shame and resolving to improve; recalling youth, anticipating a change in the weather, and writing fiction; learning lessons, loving, hating, dreading, and facing problems of thought and of action. All these and thousands of like occasions are carried through by the exercise of our psychological functions.

In the earlier chapters of the book we examine, one after another, the great functional modes that we may observe in the concrete how the organism actually (1) *apprehends* itself and other objects, as well as the active and moving panorama of life, present, past, and future (perception, memory, and imagination); (2) how it *initiates and prophetically carries out* its motor activities (action); (3) how it attempts the *resolution* of its *dramatic predicaments* (emotion); (4) how it *divines* the significance of things (inspection); (5) how it *integrates and orders* the objects and events which it apprehends, building up the structures of knowledge, valuation and social communion (comprehension); (6) and how, finally, it *sets and resolves its thought-problems* by the requisition of symbolic aids (elaborative thinking). These suggest the chief functional modes of the human adult. Their description and discussion set a central and basal problem in general psychology.

Along with this description, we must constantly refer to the living body in order to discover—so far as our present knowledge permits—the ways in which the body supplies organs, systems, and processes for the carrying on of all these functions. If we are consistently to omit 'mind' as a cause of perceiving, thinking, and the like, we shall have to look to the body alone—as we have seen—for the actual and concrete means which equip the organism to operate in all these psychological ways. Since we have omitted all use of mental and conscious terms, we may easily avoid such vexing and inconclusive problems as 'the dawn of consciousness,' 'the origin of mind,' 'the first sensations,' and the 'appearance of will.' On the other side, such physiological matters as the reflexes, the medullation of fiber-tracts, and the growth of the brain

will come in wherever they promise to throw light upon any actual performances of a psychological kind.

All of our psychological operations make their first appearance after birth and all pass through important changes throughout life. A convenient way of relating them, therefore, is through some temporal or developmental plan. We find the primordial function to be of a searching and impulsive kind. This is *primitive search.* It appears soon after birth and is directly followed by *perception-action,* a mode which involves neither a separate apprehension of objects nor a prophetic and independent action, but both together. Later this way of functioning takes the independent courses of apprehension and execution. From this point on, the organism is able independently to perceive and to act, though the earlier mode of perception-action still persists. Indeed, the residues of both of the primary functions persist throughout life in *search,* an activity which variously enriches and modifies the succeeding functions as we have distinguished them.

[7] It is perfectly true that we may expect to find psychology constantly borrowing from physiology and from the other biological subjects. Borrowing thus is as inevitable as is the borrowing in physiology from physics and chemistry, because *all organic functions* rest ultimately upon bodily structures and bodily processes. We must bear in mind, however, that a psychological function is no less psychological because it rests upon bodily processes than a physiological function is less physiological because it involves chemical changes and physical transformations of energy and can therefore be thoroughly understood only when it is referred to facts collected and organized by physics and chemistry.

These bodily means are so all-inclusive, indeed, that it has become a common remark that the psychologist is interested only in the body-as-a-whole or in the entire organism; that instead of treating of this or that organ or tissue, as the morphologist or the physiologist might, he treats of the unitary whole and of its activities. The statement is not quite exact, for the psychologist is not above making reference to the brain, the autonomic functions, or a contracting muscle under the control of a motor nerve.

It would be more accurate to say that the psychologist resorts to the *body-at-large* and does not, in general, confine himself to a single part or fraction. This would be a proper correction of the common phrase, which exaggerates totalities and unities, whether the psychologist is primarily interested in the support of his functions or simply—as the behaviorist sometimes is—in certain bodily activities for their own sake.

[8] Every psychology has assumed some principle of government, albeit the principle has commonly appeared under some other name. For the behaviorist the organism is governed by *stimulus*. Its anwser to stimulus is *response*. This doctrine in its more naïve form assumes that the energies and objects of the environment literally run the organism, calling for a causal equivalence between stimulus and response. More reflective forms of the doctrine have added such initiating and controlling factors or faculties as *instincts, habits, motives,* and *drives*. Sometimes the organism has itself been inserted in the behavioristic formula, making it read 'stimulus→organism→response.' Other psychologists have variously set up *purpose, the geneticist's genes, attention and thought, associative bonds, the nervous system,* and *personality*. Each psychology has proposed its own peculiar doctrine of government, control, and guidance. Those current psychologies which pride themselves on being 'dynamic' make a point of assuming some kind of force as a prime-mover and governor. The psychoanalyst has commonly assumed *unconscious forces* as governors (or misgovernors) of conduct. Each doctrine has a certain plausibility and each appeals to a highly selected audience which is partial to the particular agency assumed.

[9] Now the necessity of discovering all these forms of instruction, as the experiment proceeds, is that they all indicate the direction and trend of government at the moment when the investigated performance is under way. The most troublesome of all forms of government is the historical form. Frequently this is not reported by the observer (as when the past mis-naming of an orange-red has led the observer to report that color as 'cerise'). Practice series, accessory experiments, and special questioning are then depended upon to bring out the historical bias. The main

point is that the experimenter cannot, because of the varied sources of government, assume that a given presented task will elicit the functions intended unless he exercises a strict control of all those factors which enter into and direct the performance.

If you stop to consider your ordinary actions, you will see that many of them are governed by an antecedent instruction. The foot-race starts on the 'ready, go' or at the pistol shot; at tea you wait for the 'Won't you have a sandwich'; and such polite phrases as 'May we pass?' 'This way, please,' 'Will you post my letter?' 'You take the wheel.' 'May we have a window opened?' and the like, are just so many instructions to initiate and to direct your actions. They correspond, in their inoffensive and highly socialized way, to the *formal* instructions of the experiments. They are usually put into words, though a gesture or even a significant glance now and then takes their place.

But 'instruction' has the still wider use of the text. If we define it as *any circumstance which sets an immediate task to the organism,* we shall find that there are also the two other varieties of instruction to be set alongside the *formal* kind. One is the *occasional* instruction, and the other is the *self* instruction. Here 'occasional' means 'pertaining to an occasion,' as it does in the phrase 'occasional address,' which commemorates an anniversary or other such notable event. Upon entering a room I am led to apprehend a certain picture by the streak of sunlight chancing to fall across it. Here I am 'instructed' to perceive because of an occasion. When the wind blowing the curtain induces me to rise and close the sash; when the sight of the Christmas gift leads to a remembrance of the giver; when blood on the door of the motor-car throws me into a panic of fear; and when a sputter from the kitchen stove leads me to stop writing to comment upon its probable cause, I am directed by the occasion toward perceiving, acting, remembering, emoving, and inspecting. The occasion—in the sense of the general setting of the moment—introduces and directs some functional activity of the organism.

Notice that in the formal and occasional forms of instruction an organism capable of certain psychological activities is implied.

You could not instruct a snail 'to walk a little faster' without assuming that both whiting and snail were human enough to be moved by converse. Neither could you instruct an electric motor 'to turn a little faster,' though you might gain your end by increasing the electric current. To exhort or command the aggressive hippopotamus is not to instruct it, and to offer a hint for remembrance to a goldfish is not to give it a real occasional instruction.

Again, the separating out for study of an organ or tissue, as the physiologist does, is to destroy the possibility of instruction and to substitute some such device as salt-solution to keep the excised heart going, an induced current to excite the nerve-muscle preparation, or a digestive solvent to induce changes in the test tube. But when the student of physiology changes heart-rate in the dog by a harsh command or allays restlessness in the sheep by introducing as a companion a second sheep, the student has modified the physiological functions by an instruction, formal in the first case and occasional in the second. His procedure here implies not only physiological, but also psychological, modes of performance in his experimental animal. Increasing the flow of adrenin by exposing a cat to an aggressive, barking dog is another instance of the use of instruction by the physiologist.

In the conditioning processes of the Pavlovian technique, an effort is made to approximate the fractionation of the living animal —more commonly attained by dissection or mutilation—by inducing, before the conditioning process begins, a neutral or steady state of the organism into which a single instructional element of the occasional kind (electric shock, clicking metronome, flashing light) is brought in order to discover how cerebral operations may depend upon this single, simple type of occasional variant. Formal instruction (the 'influence of the experimenter') is carefully ruled out. Non-human animals succeed best in this kind of experimental setting because a formal or occasional hint to the human being may be taken in many different ways and so lead to many functional variations, which the method of conditioning does not control. This fact is often overlooked by the naïve teacher

who speaks glibly of 'conditioning' the child without having the least notion as to what is actually taking place in the youthful organism.

The self-object also appears as one of the chief and most powerful antecedents of the psychological functions. It appears in the form of the *self-instruction.* You are yourself constantly subject to its influence. Very commonly the self-object has verbal phrases to represent it; 'I never can learn to spell,' 'I'm the sort of person that . . . ,' 'I'm too tired to think it out,' 'I'd better not try,' 'I'm sure I can do it,' and countless others. In the difficulties of the study-hour, self-instruction is of the greatest moment, now admonishing of difficulties, now suggesting failure, and again whipping the organism up to maximal endeavor.

The instructions appear to the observer in many guises; *formal instruction* as a statement, request, command, caution, explanation, query, or hint; *self-instruction* as an admonition, doubt, query, comment, self-censure, command, or approval; while in the *occasional* form as many clues to the appropriate performance are offered as there are types of occasion. In addition, all three kinds of instruction may take the negative form; 'Do not,' 'I must not,' 'That does not call for,' etc.

It is common, then, to approach a functional performance—whether perceptive, memorial or imaginational, whether actional or emotive—with a certain kind of anticipative preparation which the psychologist knows as *the task* (*Aufgabe*), a preparation which is set by instruction of one of the three forms (formal, occasional and self) which we have just now reviewed. It is of the greatest importance to realize that these means of ushering in a function not only throw the organism into prompt commission but *also determine precisely what is to be done.* Here are instances. The table is covered with Christmas mail opened after the last post. I am asked to find Cousin George's greeting (formal instruction sets the task). I brush them over hurriedly (perception, action, and inspection) until the desired card turns up. Once more. The light from the table-lamp falls directly into Jackie's eyes and Jackie is expected to sleep (occasional instruction). I hurriedly turn off the light. And again. I consider that I was hasty

to have refused B my help without investigating (self-instruction) and so spend a half-hour of hard thinking in discovering a way to solve B's problem.

Here we have, then, the secret of the vast range of our daily accomplishments by virtue of a mere handful of functional modes. Just as a few simple hand-tools can be used in fabricating many products or a single printing press to publish handbills, books, and newspapers of many varieties, so are we *instructed* to the many tasks of the day; to planning, deciding and rejecting; to recalling, forgetting and reconsidering; to using spoon and fork, needle and thread, pen or scissors; to reading, memorizing or singing; to worrying, fearing or overcoming; to replying, suggesting or denying, and so on and on. Hundreds of common employments might be added to such a list without exhausting our accomplishments for a single day.

At times a performance which we have regarded as wholly unique and distinctive is nothing but a simple functional operation set by a specific instructional task. Thus what we call *active recollection* is simply remembering under instruction (as if one said 'I must recall what I did after yesterday's breakfast'); and the verbigerative recall of age is due to a persistent set which constantly favors the memorial form to the detriment of other functions.

A frequent confusion of the perceptive and the memorial functions under a specific task appears in what is known as intentional learning. Two cases must here be distinguished. (1) In the one, objects, words, or nonsense syllables are apprehended, with the instruction to learn or retain. The instruction takes various forms. It may be imposed, as in the learning experiment, or it may be self-given. The future use of our experiences is so important that we have devised a large number of learning tasks. Put into words, they run 'I must recognize this object when I see it again,' 'I must permanently retain this man's name,' 'I shall observe this clearly and responsibly,' 'I must remember that *this* goes with *this*,' 'This order must be kept for the reproduction series,' etc. We loosely call these performances learning, as if we were employing some special powers of mind when, as a

matter of fact, we are perceiving (or perceiving and comprehending) under special instruction. (2) In the other case (also included under 'learning') a task is formulated at the time of revival, *i.e.*, at the subsequent time when earlier experiences are to be used. Here the task is that of recall. The instruction is given (either from without or by the individual to himself) in an appropriate way; and the task is set of recollecting 'which syllable went with *zom*,' 'the line which followed so-and-so,' 'the name of the table-partner at Smith's dinner,' and the like. Here no unique 'acquisitive' or 'learning' function is brought into commission.

[10] Fuller accounts of many of the subjects briefly surveyed in this chapter will be found in the following writings by the author; *Psychologies of 1930*, pp. 95-114; Mind, body, and soul in medical psychology, *Amer. J. Psychol.*, 45, 1933, 577-591.

SUPPLEMENT TO CHAPTER II

[11] *The psychologist's way of regarding perception.* Common to all perceptions, then, is the fact that the objects and the events are apprehended as *present* and as *going-on-now*. So they are distinguished from memories and imaginations. Presentness is then, so to say, written across all perceptions. It does not matter what means and devices the organism has recourse to—whether the organs of sense, the apparatus for movement, the brain, the spinal cord, or the autonomic and glandular devices, are brought into requisition—so long as an object or occurrence is apprehended as of the time-being.

The perceptive characteristic of being present should not be confused with reflective decisions about the temporal placing of our objects; as if one were to say "Yes; my inkstand here or the traffic in the street yonder belongs to the present day and hour and not to things and affairs of former or of future days." That reflective placing is not the ear-mark of the perception. Our immediately inscribed presentness is the actuality of the perceived object, the temporal of-courseness which makes the object a part of the furnishings or the proceedings of the perceptual

panorama and of our own bodily existence. The immanent actuality of all that we thus apprehend is so constantly taken for granted that we may be inclined for a moment to doubt its existence. When we are, a simple comparison of one's present hunting coat, motor-car, or dining table with similar objects remembered as figuring in one's past experience will at once set in relief all that is implied in the presentness of perception.

It is common to find perception treated either in the philosopher's way, as a form of knowledge, or in the biologist's way, as a device for living. Both ways regard rather a result than a procedure. The first explains that perception turns out knowledge of a certain sort; the second that it enables the organism, by an immediate perspicacity, to obtain food, to adjust itself to natural changes, and to escape dangers. Now and then an author, following Herbart and Wundt, describes perception as an arrangement of mental 'processes' and so speaks of 'fusions' and 'colligations' or of 'qualitative,' 'spatial' and 'temporal' perceptions. Here the integrative aspect of experience is confused with performance. Our own endeavor will be to avoid philosophy, biology, and other outside views.

We cannot fully appreciate the psychologist's view of perception until we have discovered that the meaning of presentness rests upon something much more primitive in experience than the physical actuality and the independent existence of the objects which we constantly see, hear, and handle. Although our study of history must be reserved for the genetical sections, we may here notice that the specific meaning or reference in perceptive experience is not original. It has grown up little by little throughout the individual's life and throughout the vast life of the race. This fact of genesis and growth will help us to understand certain simple and primitive experiences which lie at the root of the perceptive function.

Let us illustrate by reference to the facts of vision. The psychologist has recently learned that when he wants to observe the color qualities in detachment from colored objects and sources of light he can conveniently do so by cutting a clean circular opening in the center of a large dull gray cardboard screen behind

which at a convenient distance the colored object is placed. When the round opening is observed from before the screen, the color (which should be homogeneous and should completely fill the opening) wears a curiously detached appearance. It becomes the film color or color-curtain. It no longer stands at a given distance or forms a surface or crust upon a colored cube or other solid object. It is neither flat nor tridimensional. Its distance from the eye is indeterminate. It is called a predimensional color. To observe it in its purity requires careful training in order to free it from the objective bias; but no more than the observation of the human viscera requires to be freed from the emotional bias of the layman.

Here we have a presentness, *e.g.*, a 'red presentness,' but very little more. Suppose now that we extend the perceiving and enrich the perceptive product by reaching a long rod through the circular opening and touching the colored surface. The sight of the rod, pressure from the hand, and strain from the tendons presently enable us to *place* the redness, which becomes a-red-thing-there. Now let us cast from behind the screen an uneven light upon the surface, making one half bright and the other half dark. New perceptive qualifications arise. The surface takes on texture, brilliancy and shadow. One side seems nearer, the other farther away. Once more, we may tap the surface from the rear, visibly jarring it and also apprising the observer, through the sound, of the place whence the jar arises. We only need further to provide, by some suitable means, for a gradual enlargement of the circular opening to restore at last all of the complete perceptive product with which we started when we first turned our naked gaze upon the color.

Chance experiences will supplement for all of us this account of the gradual extension of perceptual knowledge. The momentary glimpse of an unknown object seen in a dim light, strange noises heard on the plains by night, and a small unseen object passed hurriedly over the palm of the hand suggest how meager and how plastic perception may be.

When once we realize that a given bit of perceiving depends upon the exact bodily resources which the organism has then

at its command, then we have come face to face with the central psychological problem of this apprehending function. That a delicate and precise use of these resources is essential to stable and adequate perceptions is suggested by the ease with which we fall into illusion upon the spatial qualities of objects and upon the direction and rate of movement. That we perceive distance and motion best by a primary use of the eye; weight, inertia, and composition through the hand and arm, and music by way of the ear is not a matter of chance but of the exact adjustment of the means of the organism to the perceptive task in hand. Moreover, the object cannot be merely regarded as a stimulus, impressing its character upon the body. No object forces itself into the brain, there to reveal its nature and uses. The unitary functioning of the central nervous system, at the least, is always implied. Again, perceiving we must regard as the outcome of a long period of trial, success, and failure during which certain devices have been tried and rejected and certain others encouraged and brought to a functional efficacy through years and ages of individual and racial development.

The *classification* of perceptions is primarily a matter of convenience. Since the general mode is always the same, no matter what means and materials are employed, the varieties will be subject to a somewhat arbitrary choice. Our chief problem will be to describe the function, to report variations in the character, the amount, and the accuracy of the operation, and then to discover the bodily conditions underlying it. Since certain physical and extra-bodily facts are also involved (*e.g.*, the light-pattern upon the retina, the wave-trains striking the inner ear, the chemical substances acting upon the tongue), we shall have at times to include these also among the essential conditions.

[12] *The perceiving of spatial objects.* Although the apprehension of our more static and permanent surroundings (streets, trees, mountains, furniture, buildings and the rest) is closely and ultimately bound up with our perception of movement, we may, for the convenience of exposition, separately treat the two kinds.

Immediately we come upon space, for the largest part of our object-perceptions have been cast in a spatial mold. So far has

man gone in his abstract consideration of space, regarding it separately (in his geometries and in his theories of the universe) from any particular kind of filling, that we must keep clearly in view the fact that most of our common perceptions into which space enters are the perceptions of the *spatial qualifications* and the *spatial relations* of objects and events and not perceptions of mere or 'empty' space. We commonly perceive short and long, large and small, pointed and blunt objects, objects here and there, objects existing side by side, objects at rest and in movement, not disembodied length or size or place or movement. We come, then, immediately to the conditions under which spatially qualified objects are perceived.

These conditions we shall the more readily comprehend when we have fortified ourselves against two common errors under which we all fall early in life. First, we grow up with the tacit understanding that the objects which make up our surroundings are just 'there' more or less permanently and that we know them by simply opening our eyes, our ears, and other avenues of sense to allow the objects (or the knowledge of them) to walk into our 'minds.' Of course, when we reflect we see that neither an object nor a copy of it nor again the ready-made knowledge of it could enter the eye or the ear and travel along neural fibers—fibers which only suffer a chemical or molecular change of state under change of stimulation and do not 'carry' any thing or message; and when we further reflect that such a thing or message would have to be transformed into a physiological process or condition, that it would not come finally in the head to a recipient mind which awaited it, but only to other neural fields, tracts, and pathways of discharge, we realize that the easy solution of naïve common sense is no solution at all. Instead there exists, even in the briefest and simplest perceptual experience, a complication of factors which must be described in the terms of the physicist, the chemist, the physiologist, and the psychologist. We must, then, discover all the conditions which are relevant to our undertaking.

The second misapprehension, one which we have already taken steps to remove, is that our perceivings are as fixed and permanent as we suppose the objects perceived to be. To realize the fallacy

of this second supposition we have only to choose such an object as a house or a statue and then slowly to walk around it, fixating it as we go. At every step our view changes; although the object is one and the same. Every new view is a new perception, one perception gliding imperceptibly into another. When we close our eyes the perceiving ceases; when we open them again, the perceiving is renewed.

Perceiving is, then, an operation which has a beginning, a course, and an ending. Moreover, as our acquaintance with a given object increases, the perception is constantly modified. Try to perceive the table silver as you perceived it when an infant elevated to the high chair, the reagents upon your chemistry desk as you regarded them upon being first assigned to your place in the laboratory, your home as you approached it for the first time. Compare the child's apprehension of a plain gold band with that of the bride, or the surgeon's perception of his operating set with that of the patient. Compare the telegrapher listening to the click of his instrument with the chattering sound which you yourself hear as you enter his office to send a message.

Further to realize the impermanence and mutability of functional products you have only to repeat for minutes together some compound word, say, 'household' or 'tongue-tied.' Presently the halves of the word fall apart and the familiar significance disappears; then the syllables become unfamiliar, and finally the whole is resolved into an uncouth jargon. Even faces stared at intently from a short distance tend to lose their familiarity and their significance, and are replaced by vague fragments. An inverted picture may fail to supply the proper conditions for the visual perception of a landscape and fall into a hodge-podge of sketchy outlines and masses. In certain pathological disturbances of perception the object seen, heard, or explored is without class or meaning; and an emotional shock has been known so to disturb these functions that familiar objects appear strange and strange objects familiar. Such a disturbance is related in Joseph Conrad's *Youth,* where the second mate upon a coaling vessel, blown up in mid-ocean, describes his confused state after the explosion.

Psychologists have been unnecessarily labored and obscure in

discussing the 'perception of space.' Let us consider what exactly is meant by this phrase. The most obvious way to deal with space is to reduce the ordinary 'three-dimensional' world of our common experience first to two dimensions, the surfaces, and then to one, the points. But this kind of reduction, although it has often been attempted, has no real significance for us. It is geometrical, not psychological. The surface may be mathematically simpler than the solid; but it does not denote either a simpler function of the organism or a more ancient achievement of the race.

Again, the three dimensions themselves with which the psychologist is prone to begin his analysis are, for our purposes, little more than a convention. When we candidly observe the directions in which objects actually lie, we see that these directions are very many. With a great deal of detail in your present surroundings—about, above, below, near, far—you may be able to distinguish hundreds of directions. The fact that all of these directions can be *mathematically* defined by three lines crossing each other at right angles has nothing to do with the psychological analysis of space. In fact, it is not an analysis of space at all which we desire, but a statement of the conditions under which the spatial apprehension arises.

[13] For a review of the theories of the illusions see H. Ebbinghaus, *Grundzüge der Psychologie,* II, 1908, 82-121; E. B. Titchener, *Experimental Psychology; A Manual of Laboratory Practice,* Vol. I, Pt. ii, 1901, 303-328.

[14] Helmholtz and some other students of vision have thought that the mind must somehow have two unlike monocular pictures which it then either snaps together or uses in an 'unconscious inference' to acquire depth or solidity. The facts do not support this view. There is no snapping and there is no inference. When we once get beyond the delusion that consciousness is a separate device for knowledge and observe the actual bodily conditions of apprehending, we find, as in this case, that the perceiving is really functional and is specifically supported by definite bodily structures and processes.

[15] Even fixated objects may appear double under alcoholic

intoxication, which interferes with convergence of the eyes. Any multiplication beyond two is sheer fancy or else due to a muddled state which makes counting uncertain. Pillsbury says (*The Fundamentals of Psychology,* 1916, p. 298), "Of course all nearer objects (up to a fixation of 2,500 yards) are seen as double." The distance is, as he thinks, 'directly inferred.' A confusion of observation with logical presupposition! Titchener falls into the same confusion when he speaks of "habitual disregard of double images." Some writers contend that the perception of space includes a 'productive' or 'formal' factor, which creates out of the 'sensations' a spatial form. See S. Witasek, *Psychologie der Raumwahrnehmung des Auges,* 1910, pp. 11 f. Our own account does not accord with this doctrine of *Vorstellungsproduktion.*

[16] These figures are reproduced from E. H. Weber (*Annotationes anatomicæ,* 1832, pp. 50 f.), who seems to have been the first to work methodically over the body. He borrowed the method from the astronomers who had employed it in their studies of the least separation of two threads which appeared distinct. Goldscheider, applying much finer points, derived minimal values about $\frac{1}{10}$ of Weber's but showing approximately the same relative range of discrimination in the various regions. *Cf.* A. Goldscheider, *Gesammelte Abhandlungen,* I, 1898, 87.

[17] The discussion about a 'space sense' (*Raumsinn*), a 'place sense' (*Ortsinn*), and a 'consciousness of position' (*Lagebewusstsein*) rests upon the confusion of 'consciousness' with the apprehensive functions. The reference to the organism is more intimate in the exploration of the sensitive mosaic of the skin than in the distant object as seen by the eye or heard by the ear; but it stands no nearer (either in distance or in likeness) to 'processes of mind.' The confusion appears in many writers, including Wundt, James, and Titchener. Ebbinghaus creates purely 'mental acts' (*Akten psychischen Erfassen, Lokalisationsakten*) to bridge the gap between sensation and perception (*Grundzüge der Psychologie,* II, 1913, 188 ff.).

[18] The Phi phenomenon in the visual perception of movement was described by W. Wertheimer in *Zsch. f. Psychol. u.*

Physiol. der Sinnesorgane, Abt. i, 61, 1912, 161-265. The later history of the experimental studies upon this and related topics may be traced in F. L. Dimmick, An experimental study of visual movement and the phi phenomenon, *Amer. J. Psychol.,* 31, 1920, 317-332; G. D. Higginson, The visual apprehension of movement under successive retinal excitations, *ibid.,* 37, 1926, 63-115; R. F. McConnell, Visual movement under simultaneous excitations with initial and terminal overlap, *J. Exper. Psychol.,* 10, 1927, 227-246.

[19] There is no 'time sense,' as there is no 'space sense,' if we mean by 'sense' such avenues or departments as sight, hearing, and taste. Objects are temporally qualified and spatially qualified as they are produced by the processes of apprehension and the other functions. An entrance to the experimental studies on time may be gained through the following references and from current dictionaries and textbooks of psychology. J. N. Curtis, Duration and the temporal judgment, *Amer. J. Psychol.,* 27, 1916, 1-46; H. Woodrow, The temporal indifference interval determined by the method of mean error, *J. Exper. Psychol.,* 17, 1934, 167-188.

[20] Psychologists have been at pains to find some peculiar and unique factor in memory to account for its memorial stamp, for the fact that the memory fits into an appropriate past context. Several of them have pointed—as we think wrongly—to the recognition of the remembered object, to the fact that it appears familiar. Höffding, a Danish psychologist, thought that recognition depended upon a unique 'quality of knownness' (*Bekanntheitsqualität*). Wundt called it a *feeling of recognition,* which was for him compounded from the feel of the original perception plus a relaxation-feeling (*Lösungsgefühl*). Titchener takes an intermediate position, translating Wundt's *Lösungsgefühl* into a *sense feeling* of the agreeable and relaxing type, diffusely organic in its sensory character. This is for him the 'feeling of familiarity.' It accounts, as he thinks, for the recognitory function of the memorial idea. Both Höffding and Wundt propose a specific 'mental process' which has not been identified and with which we can well dispense. Titchener ventures to guess that his sense feeling is "a weakened survival of the emotion of relief" which

primitive man may have experienced in the presence of accustomed objects; an emotion which stood in contrast to the unpleasant apprehensiveness experienced before the strange and the unknown. Titchener's account, which tends to make Höffding and Wundt a little more empirical, has two defects: (1) it does not explain why our extremely common surroundings, which are taken-for-granted in direct apprehension, are as far as possible removed from strangeness, although the affective tone has died out of their perception; and (2) it does not fit well into the whole mass of memories which are not uniformly of the agreeable and relaxing type and nevertheless are recognized, *i.e.,* stamped and dated in the past. Other explanations of the recognitive character have referred it to the degree of attention (Heymans), to a process of comparison of new and old ideas (the associationists), and to the 'consciousness of self' (Dürr). As for the general matter of familiarity, there would seem to be no more reason to strain for a special explanation in memory than in perception. In the apprehensive functions objects are announced to the organism in a 'here-we-are' way whether in perception or in memory.

As for the *pastness* written across the object or occurrence, we can frequently find by careful scrutiny that the dating is due to the context, *e.g.,* adverting to my breakfast of this morning the sugar bowl is the bowl of that instant when I selected the lump for my coffee. Without this context the sugar bowl, which is always on the breakfast table, might simply be 'that dish,' a familiar object without pastness or at least without any particular pastness. At other times, the dating seems to be inherent in the occurrence as apprehended. Instants from the past flash up as we memorially regard a close acquaintance. We see *A* as standing so-and-so with such-and-such a whimsical expression or uttering a characteristic exclamation. As outside aids we should not overlook the efficacy of bodily postures, somatic states, and mimetic movements. I drop my jaw, throw back my head and gaze, and suddenly appears the Tower of Jewels as I first saw it at the Columbian Exposition in San Francisco; I square myself for boxing and in a flash I am in an excited audience witnessing a memorable bout; when

I frown meditatively a former instructor in philosophy appears as he looked in his study the first day that I began to read with him Kuno Fischer's *Descartes und seine Schule.* More of our dated memories than we know derive their temporal meaning from just such bodily reinstatements as these.

[21] Remembering, therefore, is quite different from *learning.* To learn first suggests an acquisitive function. To learn a poem is to acquire the ability to recite it without the text. To learn a language is to go through the operations necessary to the free and intelligible use of a system of verbal symbols. Neither in the learning nor in the exposition of the thing learned is a memorial reference necessary; although the memorial functions may—it is true—coöperate with others. As a matter of fact, that which we 'learn' best and most permanently bears no past date. When we recite a poem perfectly learned or seek to discover the exact phraseology to express a thought, there is, as a rule, no explicit reference to that time when we repeated the poem or when we acquired the appropriate words. As I recite a scene from Scott's Lady of the Lake or a poem by Richard Lovelace, no explicit reference to my own past appears. Whatever 'pastness' attaches to the recital concerns the time in which the scene was laid or the stanza written—not a real memory, because I was not then living. To apprehend something *as belonging to my past* is very different from using the past experiences of the organism as a means to a present recital or as an acquirement which aids thinking, perceiving, or acting. We say that we learn how to think effectively or to act skillfully or to observe with care, and so the past with its labors and successes is logically implied; but this is wholly unlike the particular form of apprehension with which we are here concerned. For the present time we treat only the apprehensive functions and leave learning for another chapter. This means that we shall omit for the present a very large literature that is frequently brought under memory, but which really relates to the conditions of acquisition and of improved performance.

It is unfortunate that the word memory has been used indiscriminately in these two senses. As a principle of conservation at

large memory has acquired a still wider connotation, implying organic change under use. (*Cf.* E. Hering, *Ueber das Gedächtnis als eine Funktion der organischen Materie,* 1876; R. Semon, *Das Mneme,* etc., 2d ed., 1908.) Most of the literature labeled memory and association falls under learning. Ebbinghaus, who wrote the first experimental monograph on memory, *Ueber das Gedächtnis; Untersuchungen zur experimentellen Psychologie* (Leipzig, 1885), explains in his preface that he uses the term to include impression, retention, association, and the reproduction of ideas. Along with most of the researches which it inspired, this classical work of Ebbinghaus is really a study of the conditions of learning or acquisition. Its English title reads *Memory; a Contribution to Experimental Psychology,* 1913.

[22] In all these ways does the context verify the object and provide for its familiarity. These are usually cases of *indirect* recognition. There is also the *direct* kind, as when we identify an article on the counter as 'the very one I saw last week' or, a particular colored paper in a laboratory series is immediately recognized as 'the one exhibited yesterday.' Here nothing can be set down to account for the recognition, unless it be the promptness and the clearness of the perception. It looks as if promptness and clearness might, at times, themselves carry familiarity. For the rest, we shall have to guess at such suggested but obscurely known bodily conditions as reduced synaptic resistance, an incipient spread of excitation (Külpe), or a peculiar kind of molecular change in the brain (Höffding).

[23] Some men have maintained that there are spontaneous memories; that memories come of their own initiative without waiting for favorable conditions. Herbart believed that ideas are forces which tend to thrust themselves into existence and are only barred from 'consciousness' by counter and inhibiting forces keeping them down. Fouillée, the French moralist, later wrote a psychology of *idées forces* (A. Fouillée, *La psychologie des idées forces,* 1893), and this doctrine has recently been revived in a modified form as *perseveration,* a term which stands for a periodic strengthening of cerebral residues, called perseverative tendencies.

(*Cf.* W. S. Foster, On the perseverative tendency, *Amer. J. Psychol.*, 25, 1914, 393-426). These tendencies have been supposed to bring memories spontaneously into existence. No one of these forms of spontaneous memories is sufficiently supported by empirical evidence to be credible. It is likely that the initiation of the memorial functions always needs a push; always needs some favoring circumstance within the central nervous system to set it going. The J. Philippe title is *L'image mentale; évolution et dissolution,* Paris, 1903.

[24] The following references suggest possible underlying differences in the memorial and imaginational functions. C. W. Perky, *Amer. J. Psychol.*, 21, 1910, 422-452; H. Clark, *ibid.*, 27, 1916, 461-492; E. B. Titchener, *A Beginner's Psychology,* 1915, 184.

In order to compare for yourself, in a first-hand way, these two major forms of apprehensional functioning, acquire visual or auditory objects suggested by the following words and insist that each fits, first into a memorial, then into an imaginational, setting: field, tree, Rebecca, ice, disappointment, Shakespeare, sonata.

[25] For example, I seem to aid *recollection* by lowering my head and rubbing my wrinkled brows, and to conjure anticipation by staring blankly ahead. Very likely these postures are remnants of former occasions. Perky inferred from her experiments (*loc. cit.*, p. 422) that the memorial function of imagery was connected with ocular movements, which she found, as a rule, to be wanting to the imagination; but Clark, who observed movements of the eye under three different methods, concluded (p. 461) that these movements were rather indicative of the nature of the objects imaged and of general states of the organism than of any functional difference in the imagery. Perky understood by imagination an imaginal presentation of some general, non-localized object, "not recognized as this and that particular and individual object." These are our objects of general reference (see the text), only one of the numerous grades and classes of apprehended things. We cannot generalize from such results to imagination at large. If Perky had taken the usual imaginational setting, where events

are rich in context and closely integrated in their sequences, her distinguishing marks for memory and imagination might have vanished. As regards observable differences at large, five independent investigators have come to conclusions so diverse (*cf.* Clark, p. 488 ff.) that we shall do well to withhold our judgment until more exact analysis and more precise definition are at hand.

[26] So, in speaking of memory, Ribot declares that "toutes ses réviviscences sont des *répetitions;* or l'imagination créatrice exige des *nouveaux.*" (*Essai sur l'imagination créatrice,* 1900, p. 3.) The opposite contention, common among the associationists, is that all the creations of art and of fancy are only reassortments from the scrap-heaps of memory. This view is as illegitimate as the other. It rests upon the analysis of objects, not upon the distinction of our psychological performances.

SUPPLEMENT TO CHAPTER III

[27] Description of the various receptors and the theory of their functions may be found in the general physiologies, in monographs, and in many current psychological texts. Examples are G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology,* 1911; W. H. Howell, *A Textbook of Physiology,* 1921 (8th ed.); L. T. Troland, *The Principles of Psychophysiology etc.,* II, 1930; various authors in *The Foundations of Experimental Psychology,* 1929, pp. 128-448, and G. L. Freeman, *Introduction to Physiological Psychology,* 1934.

[28] Fourier's law is thus stated by Helmholtz: "Any given regular periodic form of vibration can always be produced by the addition of simple vibrations, having pitch numbers which are once, twice, thrice, four times, etc., as great as the pitch numbers of the given motion." *On the Sensations of Tone, etc.* (A. J. Ellis, tr.), 1895, p. 34.

It appears that the complete analysis attained in tones is not attained in the vowel and in the simple noise. Here analysis appears to be partial or incomplete and to lead to qualities which are attributively different from the tone. The difficulty, then, is to find within the tiny compass of the inner ear a receptorial device which

will explain this fact of tonal analysis and its limitations in the vocable and in noises. Helmholtz applied to the problem the physical principle of sympathetic resonance, which is illustrated by the selective echo from the piano when you shout into it with the damping pedal pressed down. Certain piano strings are said to vibrate 'sympathetically' to the shouting voice.

[29] Helmholtz's theory is beautifully simple; but it has met with many objections. Several other devices, none of them wholly satisfactory, have been proposed. Instead of sympathetic resonance, the 'telephonic' type of theory, which calls for a vast variety of vibrational patterns or figures spread upon the basilar membrane or some other part of the organ, has been proposed in various forms. Some modified form of Helmholtz's theory, in spite of its difficulties, is still generally adhered to; but a more satisfactory account of the receptorial functions is everywhere sought. It appears likely that a definitive theory, when found, will show how gradations of analysis of the total energy-impulse delivered at the ear can account for the attributive differences in tone, formant, and noise; and will find, moreover, in the beating tone and the formant significant transitions from the simple tone to the noise, on the one hand, and, on the other, to the phonetic elements of speech. (*Cf.* W. Nagel, *Handbuch der Physiologie des Menschen,* 3, 1905, 562-572; R. M. Ogden, *Hearing,* 1924, pp. 30-47; *Foundations of Experimental Psychology,* 1929, pp. 273-349 (articles by H. Banister and H. Hartridge); M. Bentley, The psychologist's interest in hearing, *Arch. Otolaryn.,* 10, 1929, 282-295; R. L. Wegel and C. E. Lane, The auditory masking of one pure tone by another, etc., *Phys. Rev.,* 23, 1924, 266-285; E. G. Wever and C. W. Bray, Present possibilities for auditory theory, *Psychol. Rev.,* 37, 1930, 365-380; G. Kreezer, A critical examination of the investigations of auditory action currents, *Amer. J. Psychol.,* 44, 1932, 638-676, and The significance of the auditory electrical effects for auditory theory, *ibid.,* 46, 1934, 1-18; and E. G. Boring, Auditory theory, etc., *Amer. J. Psychol.,* 37, 1926, 157-188.)

[30] G. H. Parker and W. J. Crozier, The chemical senses, *Foundations of Experimental Psychology,* 1929, pp. 350-391.

[31] No structural differences among the olfactory organs have been attested which might suggest a functional differentiation of smell classes; though the facts of partial anosmia (smell blindness) and of the differential effect of exhaustion to a given chemical substance give a hint that there may possibly be a functional subdivision in these receptors. It is probable that smell in fish and other aquatic forms is mediated just as it is in man, save that the odorous substance is borne to the organism in water instead of being first dissolved in the nostril (Parker). R. E. Sheldon, The reactions of dogfish to chemical stimuli, *J. Comp. Neurol.*, 19, 1909, 273-311.

[32] M. von Frey, *Untersuchungen ueber die Sinnesfunktion der menschlichen Haut,* 1896, p. 253 ff.; K. M. Dallenbach, *Amer. J. Psychol.*, 41, 1929, 344; C. R. Pendleton, *Amer. J. Psychol.*, 40, 1928, 353-371.

[33] The following references are landmarks along the historical course of the problem of neural transmission as here briefly reviewed. H. L. F. von Helmholtz, *Arch. für Anat., Physiol., und wissensch. Medicin,* 1850, pp. 276-364; Réné Descartes, *Traité de l'homme,* 1662; G. H. Parker, *J. Gen. Physiol.*, 7, 1925, 641-669; A. C. Downing, R. W. Gerard, and A. V. Hill, *Proc. Royal Soc. London,* 100B, 1926, 223-251; J. Erlanger and H. S. Gasser, *Amer. J. Physiol.* 70, 1924, 624-666; E. D. Adrian, *The Basis of Sensation,* 1928, pp. 18-25, 91-120; K. Lucas, *The Conduction of the Nervous Impulse,* 1917; and A. V. Hill, W. O. Fenn, R. W. Gerard, and H. S. Gasser, *Physical and Chemical Changes in Nerve during Activity,* Science Press, New York, 1934.

[34] The following are representative works upon the constitution and functions of the central nervous system; W. v. Bechterew, *Die Funktionen der Nervencentra,* Jena, 1911; C. M. Child, *Physiological Foundations of Behavior,* New York, 1924; C. J. Herrick, *The Brains of Rats and Men,* Chicago, 1926; K. S. Lashley, *Brain Mechanisms and Intelligence,* Chicago, 1929; I. P. Pavlov, *Conditioned Reflexes,* Oxford, 1927; H. Piéron, *Le cerveau et la pensée,* Paris, 1923; C. S. Sherrington, *The Integrative Action of the Nervous System,* New York, 1906; M. F. Washburn, *Move-*

ment and Mental Imagery, New York, 1916; and G. E. Coghill, *Anatomy and the Problem of Behavior*, New York, 1929.

SUPPLEMENT TO CHAPTER IV

[35] We might otherwise state the relation of the objects of perception to the qualitative variety supplied by receptorial means in observing that objects possess a *double status, i.e.*, as related to the living organism, where they appear, run a course, and come to an end, when certain organic conditions are fulfilled (first status), and as attributive to the objects perceived (red fruit, gray cloud, bitter quinine, warm air, and the like). It is by virtue of the first, the organic, status that the qualities become events. This first status has also been conceived by many men as a mental status. It is to those psychologists called 'structuralists' that we owe our only clear and consistent account of this aspect of things. But with them the qualitative aspect has been considered entirely apart from perceiving itself and from those objects which the perception has been said to mean or to signify. So these qualities have been said to make up the 'elementary processes' of mind or of experience, which are, as 'structures,' totally unlike either their bodily correlates or the mental functions. Where these elementary processes have been correlated with receptors, they have generally been named 'sensations.' The psychologists of process have therefore supplemented in a useful way the physiologists' study of the sense organs by supplying a precise, though partial, account of the offices immediately performed by the receptors and other organs contributory, on the qualitative side, to the apprehensive functions.

Now while we shall make ample use of this physiological and of this 'structural' information, we shall not find it necessary to speak of mental processes; neither shall we follow the physiologists in their confused notion of the sensation as something now conceived as conscious, again as neural, and at other times as something attributive to physical objects. For us the qualities ('sensations' and the like) will be regarded either as moments in the

functions (first status) or as functional products and residues, and therefore as independent existences divorced from the performances of the organism (second status).

[36] In arranging the gray squares you would probably have found some yellowish grays and some bluish grays, and, in order to make your selected grays fit properly into the light-series, you would have been obliged to add now some blue pigment and now some yellow pigment to (say) Chinese white and lampblack. You would have found, also, that you had to add *more* Chinese white to the lampblack at one part of the series than at another in order to produce even steps between the grays. These discrepancies, then, between your final gray series and the means used to produce it will serve to convince you that what you have at the end is not a pigmental series, not a graduated physical series of any sort, but a series of qualities which reveals a gradual change in a constant direction (black to white or white to black), and a constant degree of qualitative similarity between neighboring members. Of course your series will not be entirely filled because you have had only twenty-five samples to represent the entire lot of light qualities.

[37] A second point of importance about the figure is that the hues, tints, and chromas are not separate qualities. It would not be correct to regard one blue (say the corner blue of the figure) as a hue and a pale or grayish blue as a tint or chroma. Every color quality may be defined in terms of all three of these determinations. We say that each of them exhibits hue, tint, and chroma, meaning that to place it precisely it is necessary to find its hue-place, its tint-place, and its chroma-place within the whole series. Each quality is then simple, but it has three-dimensional relations. It is as if we were to define a place in a given room as lying three feet above the floor, four feet along a horizontal line from a window, and seven feet from the door. It is, so to say, defining in terms of length, breadth, and depth. A thing is not made plural by virtue of its plural relations to other things. That would be like regarding a person as three because he had height, weight, and girth. No; every color quality exhibits a hue, a tint, and a

chroma. But the independent variation of these aspects or attributes makes it possible for us to put all our qualities into a single (tri-dimensional) system. Although we may represent this system by concrete models, painting the surfaces and edges with appropriate colors and grays, we must remember that the entire series can never be viewed at any single time and under any single set of conditions. Within its sum-total of qualities are included all degrees of illumination, from the faintest to the most brilliant, and all degrees of light and dark adaptation falling within the range of the normal eye.

Although the dimensions of the figure are determined by the relative number of qualities which the various lines represent, the whole scheme is geometrical. While, as we know, the four basal 'hue' lines are of unlike lengths, no attempt is made in the figure to lay off the exact distances. The same may be said of other dimensions. Its sole object is to give a clear notion of qualitative relationships within vision.

The pyramid represents what Katz has called the plane (*Flächen*) colors, similar to those which are seen in the fields of the spectroscope. 'Film color' or, preferably, 'color screen' would be a better term. These are simple, unlocalized, pre-dimensional and pre-perceptive qualities. D. Katz, *Die Erscheinungsweisen der Farben, etc.*, 1911, p. 8; M. F. Martin, *Amer. J. Psychol.*, 33, 1922, 451-480.

An extremely useful compendium of information upon the relation of the eye to physical light is Helmholtz's *Treatise on Physiological Optics* (Engl. tr., J. P. C. Southall, ed.), 3 vols., 1924-1925.

[38] The physicist's symbol for wave length is the Greek letter lamba (λ). The limits of the 'visible' spectrum vary with conditions of illumination and also with the state of the eye. The Greek letter μ stands for $\frac{1}{1{,}000}$ mm.; and mμ for $\frac{1}{1{,}000}\mu$ or $\frac{1}{1{,}000{,}000}$ mm. 'Limen' means 'threshold.' 'Difference limen' (DL) is a calculated value representing small qualitative (and other) differences. It is commonly defined as that difference of stimulus which leads as often (50% of the cases) to reports of *different* as to reports of *not-different.*

[39] The following table, made out in units of light-energy, illustrates the very great difference in sensitivity of various regions of the retina (reckoned in degrees of arc from the fovea outward). The results are given separately for four wave lengths, one each in red, yellow, green and blue.

LOCAL SENSITIVITY OF THE RETINA UNDER SPECTRAL LIGHTS

Degrees (O = fovea)	$\lambda = 670$ (Red)	$\lambda = 581$ (Yellow)	$\lambda = 522$ (Green)	$\lambda = 468$ (Blue)
0	.31	.16	.08	.08
5	.31	.20	.08	.08
10	.36	.31	.10	.13
20	.62	.61	.13	.20
30	2.05	1.94	.50	.20
40	3.29	2.85	.80	.30
50	4.11	3.97	1.50	.50
60	6.58	4.07	(23.80)	1.21
70	16.44	4.69	(290.10)	1.41
80	21.37	6.52	......	66.09
90	221.94	176.04	......	237.77

It appears from the table that (1) the center of the retina is most sensitive to monochromatic stimulation, (2) for a considerable distance outward (50 degrees for green and 70 degrees for blue) less energy is required to produce green and blue than red and yellow hues, and (3) at a certain degree of eccentricity the peripheral sensitivity drops off abruptly in the order green, red, blue, and yellow. The table is made up from observations reported by Ferree and Rand, Chromatic thresholds of sensation from center to periphery of the retina and their bearing on color theory, *Psychol. Rev.*, 26, 1919, 16-41, 150-163.

[40] The first view of the coöperative functions of receptor and brain, the view of peripheral determination, is presented in a fairly extreme form by Pavlov (I. P. Pavlov, *Conditioned Reflexes*, Oxford, 1927) who seems to regard the cerebral cortex as a

crumpled and folded sheet of moderate thinness which is connected with the various receptors, point by point, by way of the incoming (sensory) nerves. In this geometrical field neural connections may be made or strengthened by the process of 'conditioning.'

The second, or central-dynamic, view is presented in a fairly extreme form by Köhler (W. Köhler, *Gestalt Psychology,* New York, 1929, 111-147, 224-231, 374-376, 389-390; and *Die physischen Gestalten in Ruhe und im stationären Zustand,* 1920). The view presents the brain as an active system or field in which forces operate to organize dynamic wholes which determine, among other things, the perceptive functions. Both views take account of the orderly neural connections between central organ and receptors; but one emphasizes the primary rôle of the receptor, the other the organizing forces of the brain. Many intermediate views are at hand to be supported or weakened by forthcoming facts of neural physiology. With respect to the participation of the brain in those perceivings where the eye plays a conspicuous part, we may say with assurance that beyond the neural pathways in the cerebrum which connect the retina with subcortical regions there are processes of distribution and integration which are essential to the perceptive functions.

[41] The following are references which discuss the attributes of tone. G. J. Rich, A study of tonal attributes, *Amer. J. Psychol.,* 30, 1919, 121-164; O. Abraham, Zur physiologischen Akustik von Wellenlänge und Schwingungszahl, *Zsch. für Sinnesphysiol.,* 51, 1920, 121-152; and M. Bentley and R. Gundlach, The dependence of tonal attributes upon phase, *Amer. J. Psychol.,* 42, 1930, 519-543.

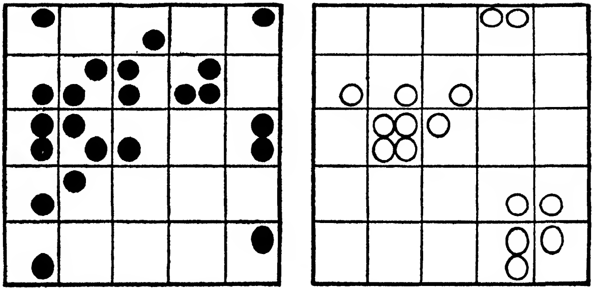
[42] Helmholtz, to be sure, thought that each vowel was composed of a series of harmonic partial-tones similar to the note, one or more of the partials being emphasized in utterance by resonance in the mouth; but Hermann objected that the mouth-cavity made its own fixed contribution (*the formant*) which was not usually harmonic with the tonal components from the vocal chords. Recent experiments under refined conditions make it appear that Helmholtz may have been right as regards the harmonic relation of the characteristic partials in the vocables

and Hermann right in his insistence upon the unique character of the factor added by the mouth, the *formant.*

[43] It should be borne in mind that these observations are extremely difficult and that upon certain points psychologists have not as yet reached perfect agreement. *Cf.* R. M. Ogden, *Hearing,* 1924, pp. 48-119; and D. C. Miller, *The Science of Musical Sounds,* 1916, pp. 215-243.

[44] Many more of the fundamental facts regarding taste and smell than are included in this brief sketch may be found in the following reference. The instructor may be relied upon for this reference and many others at his command. G. H. Parker and W. J. Crozier, The chemical senses, in *The Foundations of Experimental Psychology* (C. Murchison, ed.), Worcester, 1929, pp. 350-391. For the history of the chemical senses throughout the vertebrate series, see G. H. Parker, *Smell, Taste and Allied Senses in the Vertebrates,* 1922, and for the Henning theory of smell, see H. Henning, *Der Geruch,* 1916, (2d ed., 1924). It is obvious that Henning's theory relates most significantly to the aromatic odors, which lie on or near the front surface (FESR) of the prism. The technique of experimentation upon taste and smell qualities is well set forth in E. B. Titchener, *Experimental Psychology,* etc., I, 1901, Pt. i, 63-86, Pt. ii, 99-142. More recent experimental references are F. L. Dimmock, *Amer. J. Psychol.,* 33, 1922, 423-428, *Psychol. Rev.,* 34, 1927, 321-335; M. K. MacDonald, *ibid.,* 33, 1922, 535-553; and M. Bentley, *Psychol. Monog.,* 35, 1926 (no. 163), 144-151.

[45] In the case of compensation, no *complete* mutual antagonism (entire loss of both qualities) has been substantiated, though the reduction of one quality by another is a general phenomenon. Contrast seems to occur between each pair of the four corner tastes, though contrasts with bitter have been questioned. These interdependencies of quality upon quality are obvious, to be sure, but we should be cautious in carrying over from vision the concepts of antagonism and contrast, for, as it has been suggested (Parker), we may in the case of taste be really dealing with sensitizing and desensitizing processes by means of chemical agents.

[46] 

COMPOSITE COLD   COMPOSITE WARMTH

FIG. 50.—COLD AND WARMTH AS FOUND UPON THE SAME AREA (1 SQ. CM.) OF AN OBSERVER'S UPPER ARM.

[From Dallenbach, (*Amer. J. Psychol.*, 39, 1927, 417)]

[47] The following are standard and representative references for research whence comes our present knowledge of the somæsthetic senses. M. Blix, *Upsala Läkäreforenings Forhandlingar,* 18, 1882, 87 (for the mosaic sensitivity of the skin); E. G. Boring, *Amer. J. Psychol.,* 26, 1915, 1-57, and A. J. Carlson, *The Control of Hunger in Health and Disease,* 1916, pp. 101-118 (for visceral sensitivity); E. Murray, *Amer. J. Psychol.,* 19, 1908, 289-344 (for tickle); D. Katz, *Univ. Maine Stud.,* 32, 1930, 90-104 (vibration); N. C. Burnett and K. M. Dallenbach, *Amer. J. Psychol.,* 38, 1927, 418-431, and S. Ferrall and K. M. Dallenbach, *ibid.,* 42, 1930, 72-82 (cold, warmth, heat and burn); E. G. Boring, *Psychol. Rev.,* 22, 1915, 306-331 (visceral qualities); M. Bentley, *ibid.,* 11, 1900, 405 ff., A. H. Sullivan, *ibid.,* 34, 1923, 531 ff., and M. J. Zigler and M. Meenes, *ibid.,* 34, 1923, 542-549 (tactual and related integrations).

[48] In the digestive processes we find a similar duplication of chemical reactions which repeat, in a highly selective way, processes also to be found in nature. Some of these digestive processes are confined to the living body, to be sure, but some of them occur outside and are now reproduced in the chemical laboratory.

[49] A vast amount of experimental labor has been directed toward the discovery of the dependence of degree of fusion upon

vibrational ratio. The problem is exceedingly difficult. Its difficulty rests chiefly upon the fact that 'fusion' may be taken by the observer in many ways. The observer may report upon sheer qualitative simplicity under a searching attitude. This is the fundamental test of qualitative integration. Or he may observe the qualitative unlikeness of the members. Again, he may be impressed by smoothness or roughness; by the unitary volume of the totality; by such non-auditory accessories as 'rotundity' or 'softness,' or finally by the æsthetic property of harmoniousness. The application of the essential criterion of simplicity requires high training in the observer.

Precisely what this change under integration signifies will require a careful comparison of simple and dual qualities under separate observational attitudes for pitch, volume, and brightness, as well as for sheer simplicity. Whether this type of qualitative amalgamation is tending toward the formant and the noise, as Ogden thinks, awaits further experimental investigation. (*Cf.* W. Kemp, *Arch. f. d. ges. Psychol.,* 24, 1913, 139-181; C. C. Pratt, *Amer. J. Psychol.,* 32, 1921, 490-515; and R. M. Ogden, *Hearing,* 1924, pp. 123-149.)

[50] E. R. Jaensch has defended (*Zsch. für Psychol.,* vols. 84-92) the theory that the original memory was a photographic replica—a sort of permanent perceptual after-image, which he calls the *eidetic image.* He sustains his belief by appeal to children and animals, where he seems to find these incorporate units, which he looks upon as the antecedents of other forms of 'imaged' object.

SUPPLEMENT TO CHAPTER V

[51] Among the many works which treat generally of the topic of human learning may be mentioned the following titles. G. E. Müller, *Zur Analyse der Gedächtnistätigkeit und des Vorstellungsverlaufs,* 3 vols., 1911-17; L. J. Martin and G. E. Müller, *Zur Analyse der Unterschiedsempfindlichkeit,* Leipzig, 1899; W. H. Pyle, *The Psychology of Learning,* etc., Baltimore, 1921; E. L. Thorndike, *Human Learning,* New York, 1931, and *The Fundamentals of Learning,* New York, 1932; F. N. Freeman, *How*

Children Learn, London, 1911; T. H. Pear, *Skill in Work and Play,* London, 1924; E. J. Swift, *Learning and Doing,* Indianapolis, 1914; E. A. M. Gamble, A study in memorizing various materials by the reconstruction method, *Psychol. Monog.,* 16, 1909 (no. 43), 1-211; E. Meumann, *The Psychology of Learning* (J. W. Baird, trans.), 1913; and W. S. Hunter, Experimental studies of learning, in *The Foundations of Experimental Psychology,* Worcester, 1929, pp. 564-627. A rich bibliography of learning, done under many sub-headings, has recently been prepared by J. A. McGeoch. The psychology of human learning; a bibliography, *Psychol. Bull.,* 30, 1933, 1-62.

[52] I. P. Pavlov's large work *Conditioned Reflexes,* Oxford, 1927, may be used for deriving a firsthand account of the conditioning methods and theories. The same author has written A brief outline of the higher nervous activity in *The Psychologies of 1930,* Worcester, 1930, pp. 207-220. Conditioning regarded as a form of inclusion and substitution may be studied in S. I. Franz and K. Gordon, *Psychology,* New York, 1933, pp. 112-118. A good critical review of methods and results is H. S. Liddell, The conditioned reflex, in *Comparative Psychology* (F. A. Moss, ed.), New York, 1934.

[53] L. J. Henderson, *The Fitness of the Environment, etc.,* New York, 1913.

[54] A recent digest of the studies of skill may be found in the following article; J. A. McGeoch, Acquisition of skill, *Psychol. Bull.,* 28, 1931, 413-466.

[55] The following references will illustrate the use of the maze with human subjects; F. A. C. Perrin, An experimental and introspective study of the human learning process in the maze, *Psychol. Monog.,* 16, 1914 (no. 70), 1-97, and T. C. Scott, The retention and recognition of patterns in maze learning, *J. Exper. Psychol.,* 13, 1930, 164-207.

[56] The method of memorizing nonsense syllables in a systematic way was invented by H. Ebbinghaus. His results are recorded in a brilliant study *Ueber das Gedächtnis, etc.,* 1885, (Engl. trans. *Memory, etc.,* 1913).

[57] The various forms of context used in reading nonsense

series under the task of remembering are discussed by G. L. Freeman in The rôle of context in associative formation, *Amer. J. Psychol.*, 42, 1930, 173-212.

[58] An informing comparison of the effectiveness of learning in the maze and with nonsense material is related by J. A. McGeoch (*J. Exper. Psychol.*, 15, 1932, 662-680), who found that when he used an easy maze and 8-syllable nonsense series the syllables were better retained after eight weeks had elapsed. This result contradicts the general belief that skill is more adequately retained than verbal material. This result should, however, be considered together with the experimental evidence that the process of consolidation with nonsense materials is relatively difficult and slow; slower, *e.g.*, than with poetry, prose, or number-groups (*cf.* S. I. Franz and K. Gordon, *Psychology*, New York, 1933, pp. 443-445). Instances of the interactive influence of one phase of a function upon another will be found in the following references; B. Zeigarnik, Ueber das Belhalten von erledigten und unerledigten Handlungen, *Psychol. Forsch.*, 9, 1927, 1-85; M. Orsiankina, Die Wiederannahme unterbrochener Handlungen, *ibid.*, 11, 1928, 302-379.

[59] References for learning by parts and by wholes are the following; L. Steffens, Experimentelle Beiträge zur Lehre vom ökonomischen Lernen, *Zsch. f. Psychol.*, 22, 1900, 321-382; W. H. Winch, Should poems be learnt by school children as 'wholes' or in 'parts'? *Brit. J. Psychol.*, 15, 1924, 64-79; H. B. Reed, Part and whole methods of learning, *J. Educ. Psychol.*, 15, 1924, 107-115, 248; L. A. Pechstein, Whole vs. part methods in motor learning, etc., *Psychol. Monog.*, 23, 1917, (no. 99), and R. W. Brown, A comparison of the 'whole,' 'part,' and 'combination' methods of learning piano music, *J. Exper. Psychol.*, 11, 1928, 235-247.

[60] The subject of the distribution of rehearsals may be approached through the following authors; A. Jost, Die Assoziationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen, *Zsch. f. Psychol.*, 14, 1897, 436-472; H. A. Carr, Distribution of effort, *Psychol. Bull.*, 16, 1919, 26-28, and T. C. Ruch, Factors influencing the relative economy of massed and distributed practice in learning, *Psychol. Rev.*, 35, 1929, 19-45.

The text will return to these factors influencing learning in its sections on Animal Psychology.

[61] For critical reviews of the bodily support of learning, see K. S. Lashley, *Brain Mechanisms and Intelligence, etc.*, Chicago, 1929, and Nervous mechanisms in learning, in *The Foundations of Experimental Psychology*, Worcester, 1929, pp. 524-563; S. I. Franz and K. Gordon, *Psychology*, New York, 1933, pp. 189-260; C. J. Herrick, *Brains of Rats and Men, etc.*, Chicago, 1926; N. L. Munn, *An Introduction to Animal Psychology, etc.*, New York, 1933, pp. 334-352.

SUPPLEMENT TO CHAPTER VI

[62] The instructor will be prepared with accurate knowledge of the reaction-experiments and of other places at which the problems of action have entered the laboratory. He will explain how emphasis in some laboratories upon *the issues of action* (regarded as responses more or less accurate and more or less effective and valuable to the organism or to society) has notably modified the character of research in some quarters. An account of the nature and history of the reaction-experiment will be found in E. B. Titchener, *Experimental Psychology, etc.*, I, 1901, Pt. i, 117-125; Pt. ii, 212-227. The discovery of acting as a fundamental function of the organism is to be credited to W. Wundt. See his *Grundzüge der physiologischen Psychologie*, vol. 2, 1893 (4th ed.), 560-598.

[63] These simplifying changes are sometimes regarded as a degeneration of action. They have been exhaustively studied in the *reaction-experiment*. When the person reacting is simply instructed 'move your finger as quickly as you possibly can upon seeing the color,' it is generally found that he 'reacts' more and more quickly as time goes on.

In the parlance of the laboratory, 'the sensorial' reaction (the 'apprehensive action' of the text) gradually assumes a 'muscular' form. Without intending it, the actor has changed the determination underlying his performance. Instead of a clear perception of the initiating object or sound, he makes way for the movement. Where his self-instruction takes the verbal form, it runs 'I will

get all ready to move,' 'I must move rapidly,' 'here I go,' and so on. On the bodily side this instruction means that the movement of the hand and finger is facilitated, and so it occurs earlier than before. The entire organic set has shifted. The color or sound which before furnished a clearly perceived object now serves only as an obscure hint to discharge the movement. It appears only as a flashing change. If this motor set is further encouraged, the actor may finally approach the *acquired reflex*, where the actual movement is preceded only by a vague suspense and where it seems to come quite automatically and of its own accord. The stage of muscular reaction occupies (for vision) about $\frac{1}{7}$ second as against $\frac{1}{5}$ to $\frac{1}{4}$ second in the sensorial form; and it may further decline to less than $\frac{1}{10}$ second under the process of automatization.

SUPPLEMENT TO CHAPTER VII

[64] A method of classification which has been widely used is the historical or evolutionary method. It refers each 'primary' emotion to a corresponding instinct, which it assumes to be original and underived. The instincts are usually selected and named to correspond to the common names of the emotions; thus fear from flight, anger from pugnacity, wonder from curiosity (Ribot, James, McDougall). This method is speculative, not empirical. It seeks the causes of emotion in vaguely defined general forces with which the organism is assumed to be hereditarily endowed. In the second place, it is a theory of origin instead of a description of the emotions. And, finally, it fails to do justice to the vast variety in emotive coloring to be found in the experience of man. A related mode of classification refers to the end toward which the emotion moves, *e.g.*, bodily preservation, racial preservation, social welfare, and the like (Mercier). Into this sort of teleology no psychologist should be tempted to enter. A basis of distinction which lies nearer the psychologist's observation of the emotions rests upon the course of the feelings displayed. Thus Wundt distinguishes such emotions as rise quickly and fall slowly (*e.g.*, surprise at a sudden loud sound) from those which rise slowly and fall quickly (as hope and sorrow), and so

on. This description in terms of the temporal course fits admirably into Wundt's doctrine of the simple and the compound feelings; but it takes account only of certain affective and organic constituents in the emotions. Titchener makes the doctrine somewhat more plausible by reading sense-feeling for simple affective process; but 'agreeable-disagreeable' scarcely touches the essential difference in joy and fear, nor does 'exciting-subduing' express the difference between anger and grief.

[65] *Emotion and Desire.* The medical studies of the French psychologists, the classical writings of G. H. Schneider on the actions, and the evolutionary accounts of instinct have improved our understanding of desire, impulse, and appetition. These subjects have attained still greater prominence in the systems of Freud and his followers, who have added the concepts of 'libido,' 'conflict,' and the 'unconscious.' Out of them has come an elaborate explanatory system which has been applied to many of the problems of psychology and of medicine. Here we need only notice that desire, related to impulse (Trieb), to *libido,* and to *instinct,* has frequently been made the root of the inclinations and so the spring of emotion and of mood. While we all recognize the needs of the organism, which are always pressing for fulfillment, and the wide dependence of the emotive predicaments upon these vital appetitions, we are not thereby committed to the doctrine of the unconscious or to such an impersonation of primitive forces and faculties as we find in the speculative psychology of the psychoanalyst.

[66] For understanding the bodily implications of emoving, psychologists have used, besides the anatomical and physiological methods of examining viscera, autonomic, glands, blood vessels, and muscles, a group of *expressive methods.* The name 'expressive' derives from the very old notion that the emotions were mental structures or forces which expressed themselves through the body. The emotion was therefore approached by these bodily indicators and resultants. The methods consist in harnessing the body with pneumograph (for registering changes in breathing), sphygmograph, plethysmograph and electro-cardiograph (for heart-action and rate, volume, and pressure of blood-flow), ergograph (for muscular discharge and work), electrical amplifiers (for action poten-

tial in nerve and muscle), and galvanometric instruments, for writing down changes of potential at and near the skin.) Fig. 48 (in the text) represents one of these methods in use for registering changes in breathing, in electrical resistance of the skin, and in blood pressure.

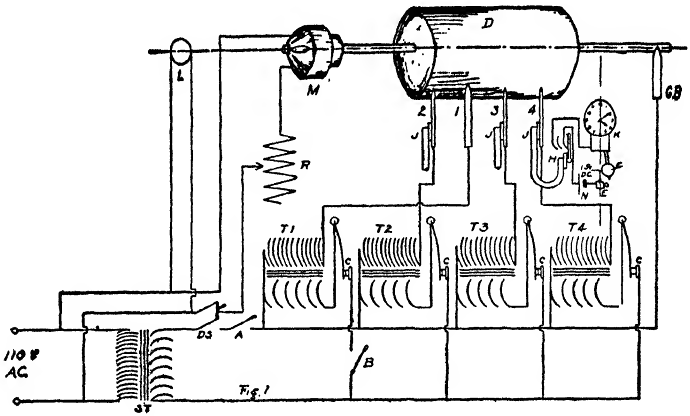


FIG. 51.—AN APPARATUS FOR RECORDING BODILY CHANGES

[From Lindley, (*J. Exper. Psychol.,* 11, 1928, 326)]

The recording drum with four writing points is shown in Fig. 51 with its actuating motor at the top. Below it are electrical circuits and controls for conducting electrical impulses from the various instruments applied to the subject and picking up the 'expressive' changes from the body. These methods are limited both by the doubtful concept of an emotion to be 'expressed' through the body and by the fact that the large bodily systems (respiratory, circulatory, muscular, and glandular) are so complex and so interrelated in function that the written records obtained by the methods are exceedingly difficult to interpret without ambiguity. This is notably true of the references to emotion, a function which involves nearly the entire body.

For a fuller discussion of the bodily resources of emotion the following authors may be consulted; W. B. Cannon, *Bodily Changes in Fear, Hunger, Rage and Pain,* New York, 1915, and

The James-Lange theory of emotion; a critical examination and an alternative theory, *Amer. J. Psychol.*, 39, 1927, 106-124; P. Bard, The neuro-humoral basis of emotional reactions, in *The Foundations of Experimental Psychology,* Worcester, 1929, pp. 449-487; C. Landis, The expressions of emotion, *ibid.*, pp. 488-523; C. J. Herrick, *Brains of Rats and Men, etc.,* Chicago, 1926, pp. 139-147.

[67] The place of emotion in psychology is discussed by M. Bentley, Is 'emotion' more than a chapter heading? in *Feelings and Emotions: The Wittenberg Symposium,* Worcester, 1928, pp. 17-23, and by J. Jastrow, The place of emotion in modern psychology, *ibid.*, pp. 24-38.

SUPPLEMENT TO CHAPTER VIII

[68] *The place of abstracting and generalizing in comprehension.* In perception we found a tendency to abstract parts and aspects of an entire object. Although we speak of perceiving an object or event as present, what we actually apprehend, in many cases, is that a present object is long or large or farther away than another or that it has changed; that an event is progressing rapidly or slowly; that one horse is passing another in the race; or that the water is falling with a roar. No object is ever exhausted by a single apprehension. On the contrary, one aspect or relation is noted and then another. So we must speak of a selectiveness of apprehension; a selectiveness which rests in part upon the limits of the organism and in part upon the predisposition (or *Einstellung*) of the moment. What is of first importance in that form of partial knowledge which is commony called abstraction is the fact that *certain* of the bodily arrangements are brought into requisition for the appropriate functions; while the rest of the body either remains neutral and non-productive or merely accessory, so far as the given apprehension or understanding is concerned. Suppose that you sweep your eye along a horizontal chalk line drawn across the board. Your apprehension of its length primarily depends upon somaesthetic processes from the pull of the eyes and the turn of the neck. The visual qualities are necessary (of course you must see the line); but so far as the length-

apprehension is concerned they are accessory. In addition, there are many other qualities present which simply do not enter into the perceptive function. This is the secret of the organism's ability to cope with one thing or one aspect at a time; namely, the use of certain appropriate resources out of the total number of present processes and devices.

This partiality or abstractiveness of function is also important in comprehension. It contributes to the topic in two ways. (1) The object or event apprehended in diverse ways may itself, when these partial views are brought together, supply a topic, an inclusive kind of knowledge which Dürr called *conceptual* apprehension (cf. H. Ebbinghaus, *Grundzüge der Psychologie,* 2, 1913, 274). We speak here of an *aspect topic.* We say in such cases that we 'know all about' the object. So *corn* or *iron castings* may be topical, derived from a multitude of partial or abstractive perceptions which have been acquired in the field or at the foundry. At no given time is all of this knowledge actualized, item by item; nevertheless the 'corn' and the 'castings' are of the topical kind which carries in a potential way our acquaintance with a definite kind of object. (2) Where the perceptual product relates to the general nature of the object, instead of to particular qualifications, the object comes to typify a class or kind: 'This is a table,' 'There goes a wild duck,' 'What a collection of books!' Here comprehension gives us something very much like the imagined object of general reference. It is not quite so general as that because it has a spatial and temporal locale; but at least it is the typical example of a whole group. Since the topic is not specifying and cumulative—as in the case of the corn and the castings—we may speak of it as the *generalizing topic.*

It appears from the experimental studies of abstraction and generalization that the organization of the 'selected' qualities automatically throws out of function the adjacent and 'outside' factors. Thus Grünbaum and Moore found that when a repeated geometrical object came to be accentuated, the remaining objects were seldom perceived. (A. A. Grünbaum, Ueber die Abstraktion der Gleichheit, *Arch. f. d. gesamte Psychol.,* 12, 1908, 340-478; T. V. Moore, The process of abstraction, *Univ. of California Publ.*

in Psychol., 1, 1910, 76 ff). One observer could draw 21 objects where he had failed to notice by 'abstraction' a repeated object, but only 3 objects where he had noticed the repeated object, and so abstracted it from the others (Moore, 124). This fact probably falls under the law of limitation of function. Thus the alleged abstraction of a single aspect or feature would be a kind of functional concentration of the organism upon a specific moment. What the direction of concentration shall be depends (1) upon some formulated task (*e.g.,* 'note the color of the rose,' 'select the largest apple,' 'look for a repeated figure'), (2) upon a fixed neural trend, or (3) upon the effectiveness of some such stimulating agent as a compelling odor or an intensely bright light.

Do not think of the abstraction as a functional performance broken into parts or bits. It gives *partial knowledge;* but no function is of itself partial. The apprehension of any single aspect or relation is just as complete as a more general and exhaustive survey would be.

A confusion of psychology with logic too often leads to the false assumption that the total object is first given and then analyzed by an abstractive process into color, size, movement, and other properties. The real abstraction occurs when we regard the object totally, as 'that thing,' without supplements which would qualify it with details and aspects. By the collection of partial aspects we either note the likeness or the difference of things with respect to their apparent height, rate, and the like, or compare various aspects with each other and proceed to acquire knowledge about their relations and dependencies, as if they had an independent existence. Thus we observe that the height of children generally increases with age or that the rate of movement in the clouds depends upon the force of the wind. When the aspects or qualities form independent topics we increase our facility with them by ascribing separate names or by the use of some object of general reference in which the aspect in question is emphasized. Thus, height, pitch, heaviness, color, and hundreds of like words symbolically represent independent qualities which have become topics; or visual images whose signification is equally abstract may perform for the organism the same service.

The final term of abstraction is reached when the object loses all individuality and *is* the class. Then we have the concept. So frequently do we fixate and express the class by a word ('animal,' 'living being,' 'justice') that we fall into the mistake of thinking that the concept *must* be indicated by a verbal symbol. The word is, to be sure, the most convenient; but the organism will make use of any suitable material at hand to supply the intended reference. Thus a simple line-drawing may be 'human being,' the raising of the upper lip and an imaged growl may be 'predacious beast,' and a general kinaesthetic stiffening may be 'courage.' In these cases we do not mean that this is a particular human being, some certain predacious animal, etc., but the class-at-large.

This entire process of abstraction, which gives us both our aspect topics and our generalizing topics, is of the greatest importance for the thinking functions, as we shall presently see.

It is a little disconcerting to discover that abstraction, taken in the sense of a departure from the whole concrete object or occurrence, appears in no fewer than three distinct functions; namely, in perceiving, in inspecting, and in comprehending. But when we see that all three of these unlike ways of operating turn out products which bear in common the mark of being abstracted, we must decide that there is no internal inconsistency. The function which is actually concerned in any given 'abstract' or 'abstracted' product is to be determined by studying the function itself. Thus when the exclamation 'A giraffe!' arises from a sheer apprehension of the strange beast 'as present,' we have a tinge of abstracted 'giraffe-ness'; when we pass beyond perceiving and scrutinize the peculiar shoulders and sloping back (perhaps with the comment 'an unearthly creature') we turn out an inspective product, and, finally, when we deal with giraffes as a class and operate topically with this animal form we are using the mode of comprehension.

[69] *Aids to, and substitutes for, the topic.* The body is exceedingly resourceful in supplying materials for holding and for enriching the topic and also for devising temporary substitutes for it. As I now propose 'prices' as a topic for my consideration and yours, I have before me the market page of

the morning paper, while the 'hunger' topic is typified by the sound of feet homeward bound upon the walk outside. Here the apprehended object is not so much an object as it is a concrete surrogate for, or representation of, the topic. Again, the organism is clever in its use of postures, strains, and attitudes, upon which it builds its topical constructions. Fortitude is much more vivid and permanent when I set my jaw and straighten my spine; time is clearer when I suspend my breath, as if listening to something which passes; trouble literally feeds upon a frown and the feel of a dour visage, and industry upon a vigorous fumbling with the pen and a fixed stare at the paper. When present objects, movements, and postures fail us, we have recourse to shreds of imagined objects for our topical representatives. At the moment, labor is typified by the familiar arm-and-hammer figure on the political ballot, and peace by the white dove and the suave cadence of a demagogue's persuasive voice. These shorthand and symbolic presentations are especially useful where the presentation is brief, lacking opportunity for expansion of the topic on its various sides.

Another resource is the mood. James remarked that it was impossible for a vigorous youth in abounding health to dwell upon the topic of death and of his own tomb. Cellini, half starved in prison, had visions of ministering angels and of heavenly feasts. The melancholy dyspeptic proverbially turns to lugubrious subjects, where the jovial man naturally adverts to topics of cheer. Not only does mood strengthen the appropriate individual object, it also sets and encourages whole topics which are congruent with its temper.

In speech, topical discourse is enormously extended by verbal symbols. The mere name of the topic, where it has a familiar ring, is sufficient to start the comprehensive functions. The art of conversation demands that words shall carry a topic of common import to speaker and hearer, the hearer clothing and enriching it from his own psychological resources. The art of developing the topic in conversation is beautifully displayed in the classical *Dialogues* of Plato. The skillful lecturer avoids the necessity of too much thinking in his auditors. Instead he develops topics with sufficient deliberation for each hearer to provide his own filling.

The speaker should not forget, however, that some hearers are obliged to translate his verbal symbols into other forms before he topic develops for them in a significant way.

[70] Binet had in view this sort of 'intellectual' person in his early studies of *l'intelligence,* which came nearer this aspect of the intellect' than more recent views of an 'intelligence' which s to be measured by the clerical exercises of the 'intelligence test.' (See A. Binet and T. Simon, Méthodes nouvelles pour le diagnosic du niveau intellectuel des anormaux, *L'Année psychol.,* 11, 1905, 196.)

[71] The relation of searching to inspection and comprehension s discussed from an experimental point of view in H. L. Kingsley, Search; a function intermediate between perception and thinking, *Psychol. Monog.,* 35, 1926, (no. 163), 16-55.

[72] Experiments upon this form of insight will be found in M. E. Bulbrook, An experimental study into the existence and nature of 'insight,' *Amer. J. Psychol.,* 44, 1932, 409-453.

SUPPLEMENT TO CHAPTER IX

[73] The curious German word *Bewusstseinslage* has usually been translated *attitude;* though the original word is frequently retained in English contexts. 'Attitude' is unfortunate because it s also employed in quite another sense; namely, the way in which objects and situations are taken by the individual. Thus one takes an interested, observing, or aggressive attitude toward omething or somebody. In our present context, we shall use the erm 'flash' or 'flashing intimation.' For a review and bibliography of the works on *Bewusstseinslagen* see E. B. Titchener, *Lectures on the Experimental Psychology of the Thought Processes,* 1909, Lect. iii; and T. V. Moore, The process of abstraction, *Univ. of California Publ. in Psychol.,* 1, 1910, 76 ff. In these experimental tudies the methods chiefly used were the test (Binet and Woodworth), various forms of the reaction-experiment, modified in he direction of association and recall (Meyer and Orth, Watt, Ach, and Messer), and the simple propounding of questions deigned to arouse thinking (Messer, Bühler, and Störring).

[74] *Thought and action-determinations and the flash.* Ach made an intensive study of the thought-determination by an examination of the preparatory period of the reaction-experiment. Although his study bore directly upon action, Ach's view of determination led him and also others to apply it to the problem of thinking. The observer was instructed to move his hand in such-and-such a way when such-and-such an object was visually presented. Here even more clearly and definitely than in the task of thinking (as in Watt's experiments) the preparatory period is signalized by a fixed anticipation. Ach found a prophetic idea of the movement which was related to the coming stimulus-object, and, on the side of the nervous system, he assumed a 'determining tendency.' G. E. Müller rejects the determining tendency, which he regards as a voluntaristic concept of a mysterious sort; but he substitutes something very much like it in his 'idea of goal' (*Zielvorstellung*) or 'directive idea' (*Richtungsvorstellung*) plus a 'mental disposition' (*Zur Analyse,* iii, 540). On Müller's admission, the goal-idea (virtually Watt's task, with a wider connotation to include self-instruction) has a peculiar and impressive efficacy. It commands attention, it possesses interest, and interest serves to lend it a stronger perseveration and a greater associative effectiveness (429). Since both parties to the controversy have in mind the same functional fact, variously called the task, the awareness, the determining tendency, and the goal-idea, we may retain the names to express, as occasion demands, its various aspects. We shall not assume with Ach that the determining tendency connotes an unique factor of 'will' ultimately different in kind from the reproductive tendencies of Müller. At the same time, all the factual descriptions imply that the task has a distinctive issue in the thought- and action-solutions, not common to other associative formations. At present we may only say that the thought-task represents a total functional stage, which releases or commands a group or constellation of neural processes relevant to the proposed problem. It may be only a peculiar grouping of reproductive tendencies (whatever in the nervous system these precisely are—possibly a disposition of energy) which are capable of furnishing the materials necessary to a novel solution. As in

perceiving, matters relevant to a solution are assembled. But in thought the assembling derives, not from an arrangement of stimulus, not wholly from any previous central integration, but from a problem which somehow invites the presence of symbolic tools appropriate to elaboration.

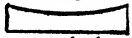
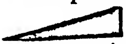
When we put together Watt's thought-task and Ach's determing tendency we really have characterized from two sides one and the same thing, namely that stage of a unitary function which lays the train for, and develops into, the second, *i.e.,* the elaborating stage in thinking, and the performing stage in action.

The debate upon the 'determination' of thought turns as often upon terms and standpoint as upon the actual facts. The Müllerian or Göttingen party denies the existence of the flash (*Bewusstseinslage*), the awareness (*Bewusstheit*), the 'imageless thought,' and the thought elements (*Gedankenelemente*), preferring to write its entire psychology in 'associational' terms. The chief opposing party, which has sprung from the laboratory at Leipzig and the Würzburg School, is friendly to the voluntaristic psychology of Wundt, emphasizing apperception and a multiplicity of feelings and activities. It has made extensive use of a peculiar method, the method of question-and-answer or 'examination' (*Ausfragemethode*), which Wundt condemned as unscientific (*Psychol. Stud.,* 3, 1907, 334; *Arch. f. d. gesamte Psychol.,* 11, 1908, 445). In the hands of Messer and Bühler, the standpoint came to be that of 'intellectualism' as set against 'sensationalism' and 'associationism.' The chief exposition and defense of a descriptive account of thought and action in terms of association and reproduction have been made by Müller. His long series of studies culminating in the compendious publication, *Zur Analyse der Gedächtnistätigkeit und des Vorstellungsverlaufes* (3 vols., 1911-17), is among the most notable of all inquiries into the psychological functions. Although Müller is not wholly clear upon the distinction between process and function, his ideas (*Vorstellungen*) are, for the greater part, 'meanings,' sometimes primary and sometimes symbolic; and the flow of these ideas he seeks to bring under the laws of reproduction (*Reproduktionsgesetze*). In rejecting flash, *Bewusstheiten,* and the

rest, Müller does not merely substitute the old formal laws of contiguity and resemblance, but instead uniformities which have been substantiated by experiment; *i.e.*, the laws of substitution, perseveration, inhibition, coöperation and convergence. In addition, he makes use of the laws of 'limited range' and of 'transitoriness' (*Enge und Unbeständigkeit des Bewusstseins*), of the facts of attention, and of the hypotheses of predisposition (*Einstellung*), and central, 'non-mental' influences (*apsychonome Einflüsse*). "Man verstehe den Ausdruck 'Erklärung durch die Reproduktionsgesetze' stets in dem durch diese Einschränkungen gebotenen relativen Sinne" (vol. 3, 426, footnote). Although this associational psychology makes free use of many conceptual terms, *e.g.*, active recall, memorial activity, directional and goal ideas, perseveration and *Bereitschaft*, its methods are more empirical and its factual materials more nearly adequate than are those of the opposing party.

The awareness of Ach is, so Müller contends, either a group of fleeting and obscure ideas, like any other bit of information, or else it is 'knowledge' of the same kind as knowledge of one's own name, of one's birthplace, of one's ability to remember the names of the American presidents or the ability to carry through a complicated action or to withstand hardship; *i.e.*, it is *potential* knowledge;—an assurance that one could, upon occasion, name, remember, do, think out, or endure. When one says, 'I know my name' or 'I know that piece of music,' the name or the composition is not actually present. To know in these cases then expresses not real knowledge, as of something now run through in detail, but a conviction that one has such and such resources at command. Remember that these alleged 'awarenesses' come with repetition and practice; that is to say, after the observer has time after time carried through the task, and may therefore reasonably expect himself to succeeded at the next attempt. The point is important. It will not do to import into the plain description of thinking a confusion of knowing-now-in-process and a sheer flash of conviction. This flash represents rather the indicative than the referring and objectifying aspect of functioning, and we should not therefore expect to find an elaborate mass of product supported

by an equally elaborate mass of 'sensation' or 'image.' To speak then of 'imageless' thinking in such a case is both misleading and confusing. Again we must—so long as we hold the functional view of the organism—free ourselves from the doctrine of parallelism and accept just what we find to be actually present in the operation.

[75] G. E. Müller has shown that even nonsense syllables may carry this kind of reference, *i.e.*, that the apprehension of a nonsense object 'arouses the idea of another object which is symbolized by the first.' Thus a syllable of three letters whose first and third members were more impressive than the middle carried the geometrical meaning  ; an impressive middle letter was represented by △ ; and the number-series, 1, 2, 3, 4, . . . by  . These symbolic objects sometimes serve as aids to memorizing. Then they fall under the heading of mnemotechnical devices. Colvin found a like symbolic use (which he calls 'mimetic') of somaesthetic complexes, a kind of inner sign-language which replaced words. Thus a nonsense series was represented by a sequence of movements which meant their arrangement and order. Colvin believed that these somaesthetic symbols were remnants of gestures and bodily poses. Both instances are interestng in this connection because they represent typical means of supplying—along with words—highly abstract materials for thinking. They also throw light upon the history of the flash, which, as we have seen, plays an important part in elaboration. G. E. Müller, *Zur Analyse der Gedächtnistätigkeit und des Vorstellungsverlaufes*, 3, 1913, 385; S. S. Colvin, *Psychol. Rev.*, 17, 1910, 263 f. K. Koffka, who also remarked the symbolizing visual image, similar to Müller's, thought it attached to the *Bewusstseinslage*. (See his *Zur Analyse der Vorstellungen und ihrer Gesetze*, 1912, p. 265.)

[76] Like the apprehended object, the topic, the thing learned, and the movement-end of action, the flashes lie, not in the realm of the mind, but among the performances and accomplishments of the organism. If they are to be called imageless, it would be better to admit that the adjective tells us nothing at all about the factors implied in their existence. It is unfortunate that the

word *image* should have been used both for a *process of mind* and for all those remembered and imagined *objects* which do not depend upon the organs of sense. This ambiguous use has led many persons to believe that the facts underlying 'imageless thought' are somehow descriptive of the mental side of the organism. The imageless thought is no more to be analyzed by the psychologist into mental parts than the perceived tree, or the remembered house, or the object symbolically presented in the word.

SUPPLEMENT TO CHAPTER X

[77] From this hurried review of the manner in which pattern appears in the various functions we may draw one or two very significant inferences and generalizations. In the more primitive perceptions, pattern is most clean-cut. And here it is most directly related to the integration of stimulus and neural excitation. In fact, we have professed to find in this active relation of the organism to some limited feature or aspect of the immediate surroundings one clue to the beginnings of the apprehensive functions. But this clue must not mislead us into the belief that the main psychological occupation of the organism is simply to go on mimicking and repeating outside events. Nor should it induce us to think that the main course of development is simply a heaping up of the initial patterns. That sort of undue emphasis upon the simpler forms of perceiving would lead us back toward the stereotyped fixtures of mental structure and of stimulus-and-response. Although receptors occupy a dominant place in perception, we must observe (a) that the *whole living organism perceives,* brain, nerves, muscles, and viscera being brought into requisition, and (b) that the gradual development of our functions leads directly away from the primacy of the receptor as a dominating factor in pattern and toward its subordinate position in the functions at large.

We have just now seen that pattern tends to become foreshortened in comprehension and in certain actions and that it may almost wholly disappear in search and in elaborative thinking. Even in remembering and imagining, where we are too apt to

assume that we are dealing with something like the copies of original perceptive patterns, careful scrutiny of the facts soon convinces us that it is the product and outcome of these functions which 'copy' their perceived counterparts (*i.e.*, objects as remembered or imagined). The organism here contrives to use all manner of substitutes for the more photographic patterns. As a matter of fact, it is within the range of perception itself that we discover an immediate and insistent tendency to ellipsis and to substitution for the more primitive patterns initiated from the receptors. Thus a mere flash of visual or auditory excitation soon comes to suffice for an elaborate and precise perception of flying bird or screeching fire-engine, and the panorama of any dream will instruct us that, under certain conditions, the receptors are either indifferent or wholly inadequate to the actual perceptive performance. Especially where perceiving is fused with inspecting and with comprehending does the primacy of the pattern notably recede. This fact we readily appreciate when we inspect the strong coffee for the trace of sugar, identify the breed of the friendly hound, and catch the drift of the indistinct radio announcer. Patterns there are in such cases; but we dissect, shred, or change them according to our scrutinizing and comprehending needs and purposes.

A useful counterblast to the undue and exaggerated emphasis upon the featured pattern of our psychological functions (an exaggeration common in sensationalistic psychologies) is the fundamental characteristic of *search*. From the psychological beginning of life, search plays a leading rôle. The getting-ready, the pushing-on, the tending-toward, which we have found to be supported by the primordial characteristics of coherent human living, is quite as deeply grounded in our psychological performances as is the ordered patterning now under survey in its more general implications. But, on this side, again, it is quite as easy to be intemperate, as current doctrines of 'purpose,' 'instinct,' 'libido,' 'drive,' and their kind, at once instruct and warn us.

Another factor determining the course and outcome of apprehension is known under *the principle of constancy*. In whatever position, form, or context a given object appears we tend to perceive it as the same object. Under whatever illumination the

color of a given object appears, we tend to apprehend it as a single constant color. Here we see the effect of apprehended products upon the function. We see a table as oblong from whatever aspect we view it: we see snow as white until grime and dirt make it actually black, and even then it is difficult to give up the whiteness of a substance which is 'essentially' white. Here is invoked the fact of stabilization which we have found to be one of the directions of change under exercise and repetition of the functions. When objects and events have hardened into typical and representative forms, possessing typical and representative attributes and properties, we apprehend those forms and those properties, and thus, to a very high degree, do we neglect the specific action of stimuli, remolding the function and its products in a certain direction. The principle may also involve other factors entering into the constitution of pattern. Experimentation has, within the last few years, greatly extended our precise knowledge of the facts of 'constancy' and of the conditions which govern it. Entrance to this field of experimentation may be gained from R. B. MacLeod, An experimental investigation of brightness constancy, *Archives of Psychol.,* 1932, no. 135.

[78] Since we are concerned here with full measures, the word *capacity* suggests itself as a suitable term to designate the top limit of function. We speak of the capacity of a vessel as a quart or a gallon and the capacity of a power-plant as so many thousand kilowatt-hours, meaning that when the vessel is filled to its limit or the plant is delivering its total power such-and-such an amount is attained. But capacity also conveys the meaning of a *potential* measure; it indicates the possibility of a fixed limit when the limit is not actually attained. Thus we remark of a university student that he has a large capacity for accomplishment, although he never exerts himself; implying that he has latent powers which diligence and persistence would utilize. At times this potentiality is made specific, as when a child is said to give evidence of a capacity for music, drawing, or mechanics. Used in this sense, capacity is practically the same as an unused talent which may be employed or kept in reserve. Again, the term is frequently made to designate an assumed inherited resource. Thus Thorndike

adds capacities to reflexes and instincts, as general racial endowments; as endowments which constitute a part of the 'original nature of man.' (E. L. Thorndike, *Educational Psychology,* 1, 1913, 5.) All of these common uses of the word capacity render it unsuitable for our own present purposes. When applied to functional measures of the organism, they suggest too strongly the existence of faculties or gifts of nature which have a real but hidden existence. Once we gave this name to the assumed cause or condition of a functional performance, we should presently come to think of it as a real force and clothe it with convenient attributes. This is the insidious error of 'the faculty,' which has done great injury to the physical and biological sciences, as well as to psychology. When used in its common definition, *potentia recipiendi aliquid,* the term capacity is closely allied, in the history of thought, to the concept of *energy,* the capacity for doing work. (Cf. R. Eisler, *Wörterbuch der philosophischen Begriffe,* 1904.)

[79] W. James, *Philos. Rev.,* 16, 1908, 1.

[80] Most animal psychologists of the last few years have found the non-human forms to be primarily motivated by the bodily lusts of sex, hunger, and thirst; while the human behaviorists, taking their cue from these studies, have tried valiantly to show that men also derive many of their chief springs of action from the same ancient sources. Fidelity to his SR formula, however, compels the behaviorist to look also to stimulus (S) to drive his bodily mechanisms through to the issues of response (R). The more moderate behaviorists, it must be said, now extend their motivating causes to the energies of the body itself, in muscle and nerve, brain and blood, endocrine and autonomic. For the organization and the extension of these motives, they also call freely, if vaguely, upon Pavlovian conditioning and other theories of learning.

The educationists, who must have motivated children to educate, commonly fall back upon an 'original nature' which is throbbing with restless energies and capacities. The psychoanalysts prefer—as everyone knows—to revert to a more primitive and savage notion of the folk-soul, which serves to drive, as well as to harass, the individual throughout his life-course.

Our own conception of those conditions which actuate man brings in *the presented occasion and all the bodily parts and states* which reciprocate with this occasion and which directly underlie the functions of the moment; brings in all the antecedents of function (recent and remote); and brings in, finally, all those products and issues of function which the organism psychologically produces and among which it subsequently makes its way through life.

[81] Another circumstance which complicates the art of measurement is that the magnitude which we propose to measure does not always imply divisibility. When a dozen toy balloons suddenly released float away into the heavens it presently becomes obvious to the onlooker that some of the receding objects look small, having been swiftly carried away by air-currents, and others look large. Some are correspondingly far away and others are near at hand. Neither of these estimates of magnitude (size and distance) waits upon the reflection that one balloon appears to hold 75 cubic inches (or to be 4 inches in diameter), another 200, and another 450; or that one is 50 yards away, another 80, and still another 300. In other cases, a difference of 'magnitude' may with assurance be predicated when no division into parts is at all possible. My satisfaction at the election to office of my candidate is greater than at the discovery in my pocket of the exact street-car fare. The mother's anxiety over the lost child exceeds her anxiety lest the bread burn. The smart of heat upon the fireman's face exceeds the smart when a match approaches the cheek. One is more hurt at a friend's justified reproach than at a challenge from the traffic officer. It thus appears that spatial magnitudes can, at least in theory, be divided and scaled by units; but that some other forms of magnitude may not—even in theory—be subject to division.

While the phrase 'mental measurement' is commonly used, it is very doubtful whether the principles of measurement are really applicable here. We may ask whether the notions of 'mind' and 'measurement' have ever been successfully combined. They belong to quite different contexts. But it is perfectly feasible—at least in principle—to express the amount of functional performance in

terms of the functional product. Just as a secretory process may be measured in terms of the substance secreted, so may we measure the perceptive or memorial performance in terms of the number of like objects perceived or of the nonsense syllables remembered under assigned conditions.

[82] In psychophysics a very large number of 'judgments' or 'reports' are given by a highly trained individual under carefully controlled conditions. These reports vary among themselves from moment to moment and from day to day. They are said to be subject to *accidental deviations*. The statistical treatment of them is designed to discover and to state in a quantitative way the form and the extent of their distribution. On the other hand, the *T*-methods set a given task to many individuals and they make a similar assumption about this distribution of the performances. When a thousand persons perform the same task (*e.g.*, carry through a number of simple multiplications), the *T*-methods assume that the time occupied or the mistakes made will be distributed in a way which can likewise be statistically described. Each result is supposed to be subject to deviations. The statistical description, then, in this case, applies to the whole group of individuals; just as it might give the plan of distribution of statures in an army of men, without saying anything about any single individual soldier, except that he occupied a certain position within the entire range of heights.

The two sets of method suggest the distinction between microscopic anatomy and gross anatomy. The *P*-methods are at great pains, using the most refined tools of experiment, to discover and to quantify some simple and fairly constant function of the individual; while the *T*-methods start with a gross, unknown, and undefined performance. Instead of assuming, as the *P*-methods assume, that this sample is subject to large variations, the *T*-methods accept it straightway as representative of the individual and throw it into a mass of samples similarly secured from many other individuals. Thus the individual *variate* (the test-result from a single person) is only a sample of all the varying performances of that individual. The *T*-methods may be said, therefore, to involve accidental deviations of two orders. It is a question, how-

ever, whether the gross procedures of testing do not sometimes introduce deviations which are larger than the total range of variability of individual performance. They are certainly much larger than the *P*-methods could tolerate. The statistical refinement of the *P*-methods begins where the statistical refinement of the *T*-methods leaves off. In spite of the like mathematical foundation of the two types, the degree of refinement, then, as well as the unlike history and context, which we noticed before, compels us to treat them as different methods.

[83] *The psychophysical methods.* The methods of psychophysics were alleged by Fechner, their founder, to measure sensation—to measure and also to set it into exact relation to measurable quantities in the physical world. Fechner maintained that sensations could be indirectly or substitutively measured. (G. T. Fechner, 1801-1887, *Elemente der Psychophysik*, 2 vols., 1860.) Taking Weber's observation that the intensive increase of pressure ran parallel to a proportionate increase of weights laid upon the skin, so that *e.g.*, the increase of 10 drams to 22 drams gave the same intensive increment as the increase of 10 half-ounces to 22 half-ounces, or of 10 ounces to 22 ounces, Fechner generalized this relation obtaining between sensation and stimulus and called the generalization Weber's Law. As Fechner derived it, the relation was logarithmic; sensational intensity was said to be proportional to the logarithm of the stimulus. (For a brief discussion of the facts, *see* W. B. Pillsbury, *Fundamentals of Psychology,* 1922, 2d ed., pp. 194-198.)

Now the fact of the dependence of sensible intensity upon the relative difference of two stimuli is indubitable. It has been verified by many observers for the middle range of intensities (not for the weakest and the strongest), in brightness, noise, tone, pressure, strain, and smell. But Fechner made the mistake of assuming that a given intensity was made up of a number or 'multitude' of little *unit* intensities, as the hour is resolvable into seconds and the mile into feet. Thus he thought that he could regard sensation as a mathematical function of the physical energy released by the stimulating agent. But intensity is not a 'multitude.' It does not run up by degrees from zero. It is just itself.

It is not divisible. Hence it cannot be laid along a scale of intensities and measured in terms of a unit-intensity.

An enormously complicated discussion upon the matter of measurement in psychology arose after Fechner's exposition. G. E. Müller and others objected to Fechner's measurement of the sensation. It was maintained, however, that *sense distance,* based upon the observed *differentness* or disparity of the sensations, could be measured. (For historical surveys of the discussion consult E. B. Titchener, *Experimental Psychology,* II, 1905, Pt. ii, xiii ff.; E. G. Boring, *Amer. J. Psychol.,* 32, 1921, 440 ff.; Warner Brown, The judgment of difference, etc., 1910, *Univ. of California Publ. in Psychol.,* vol. I, no. I, pp. 1-71.) It was pointed out that two slightly different sensations, *a* and *b,* were directly apprehended as of a certain unlikeness and that this degree of unlikeness could be represented by a definite sense-distance, *a—b,* which might be duplicated over and over with other sensations, as *c—d* and *l—m*. Since this sense-distance can be equated to other like sense-distances, in other parts of the intensive scale, it may, so the new argument ran, be regarded as a unit and other sense-distances actually measured as multiples of it. To make the matter of measurement more plausible, it was argued that distance, taken in the same sense, is always implied in any unit of measurement. In the linear scale the inch is just the differentness of two positions (the ends of the inch) regarded as establishing a 'stretch' or 'distance,' which may be taken over and over in the process of measuring. The unit first settled upon was the just noticeable or the smallest noticeable difference (*j.n.d.*), whether of intensity (strong or weak), quality (color-hue, tonal pitch), extent (tactual or kinaesthetic distance), or duration. *Just-noticeability* is not, however—as it seems to be—a matter of direct observation but of inference. No sense-distance wears upon its face a 'just noticeableness.' It is now common to replace it by the *liminal* or threshold difference (*DL*), a calculated value standing midway between difference and no-difference (equality or uncertainty), and derived by the mathematical laws of probability.

After a long and extremely acute discussion, in which the concept of measurement, as developed in mathematics and in the

physical sciences, was carefully analyzed, psychologists generally accepted the notion of the sense-distance and rejected Fechner's contention that the sensation was a divisible or at least a measurable magnitude. A given disparity or unlikeness of intensity, for example, was taken as the unit and compared with other distances which were found to be either like it or different from it. Thus the *comparison of sense-distances* was set up and made the basis of measurement.

How the P-methods measure function. The exclusion from our psychology of existences of a 'mental' sort with the omission of 'sensations' and of 'sense-distances' may seem to throw the psychophysical methods out of our account. That would be a hasty inference. What all these men were actually measuring turns out to be—when we disregard their theories about mind—just the precise and controlled inspection of simple, unequivocal differences between tones, colors, lights, pressures, and the like, and the report of them as 'the same' or 'different.' A variant of this inspected difference is 'present' or 'absent.' A weak sound or light is reported as 'present' (*i.e.,* heard or seen) or 'not-present' (*i.e.,* not heard or seen). There is no real difference in the psychological function whether the observer reports 'likeness-unlikeness' or 'presence-absence.'

Now the *P*-methods, as used to measure this function of inspection, contain two essential parts. The first part is *devising the experimental setting* where finely graded and measured sounds, lights, pressures, and so on, can be presented to a trained observer. The second part of the method *provides a statistical means for treating and interpreting the reports* of the observer. You might think that with constant conditions and careful instructions, the reports would all be the same. But at times they are not, and for two reasons. First, the stimulus-energies of the sounds, lights, pressures, etc., are varied in a haphazard way. Thus you may have a series of 5 or 7 sound-energies, which are discriminated with varying degrees of frequency, ease, and accuracy. Again, even if the sounds possessed a like physical energy (as stimuli to the auditory nerve), *the organism would itself vary its functional aptitude* from observation to observation and so discriminate in a varying way.

The statistical treatment rests upon the mathematical 'law of error,' and this law has been found to apply to the way in which the organism discriminates under like and unlike stimuli and stimulus-differences.

(i) A weak stimulus (say, sound or light) is presented, and the observer reports that the appropriate quality is present (or is not-present); (ii) two similar stimuli (say, two moderate sounds from falling steel balls) are given in succession and the observer reports an intensive difference (or its want); or (iii) two unlike pairs of stimuli (say, two moderately weak sounds and two moderately strong sounds) may be given and the observer reports the intensive differences as the 'same' or as 'different.' Always the abstractive inspection of sheer presence or of difference. And this means, at bottom, observation under the task of discrimination—the discrimination, *e.g.*, of sound from no-sound, of one sound from another, or of one sound-difference from another.

In order that 'the law of error' may be successfully applied in measuring the limits of this psychological function, it is of the greatest importance that the discriminating be done time after time in precisely the same terms. Suppose that the sound is produced by steel balls falling from various heights, the sound-energy striking the ear with various degrees of energy. The report of 'likeness' or 'difference' may then rest upon (a) a visual image of the dropping ball, (b) a mixed visual-auditory image which means 'there it strikes the support,' (c) a somaesthetic perception of the stroke of the ball, (d) a verbal comment, 'It is striking hard' . . . 'striking light,' or (e) a dynamic perception of the impact at the end of the fall. No one who has not actually observed in the psychophysical experiments will conceive the large number of ways in which so simple a discriminative inspection as that of a falling ball can be taken. And with every different way the functional performance differs.

Pratt has given an impressive illustration of the diverse ways of apprehending the relation of two simultaneous tones, and others have done a similar service for the perception of place or of disparate localities upon the skin. The important methodical point at issue is that any variable and uncontrolled factor (save

the 'constant' errors which can be calculated and the 'accidental' deviations which are inherent in the organism and are included in the final measures of central tendency and of distribution) is to be eliminated from the experimental setting. (C. C. Pratt, *Amer. J. Psychol.*, 32, 1921, 490. Pratt showed that the bitonal relation might be based upon smoothness, simplicity, feeling, volume, rotundity, and other criteria of duality. Where spatial objects are perceived we may well expect still greater ambiguity; E. G. Boring, *ibid.*, 32, 1931, 465 ff.)

Since we are measuring the topmost reach of function, we must make the conditions of discrimination of like and different, of present and absent, extremely difficult. This is done by having the sounds to be distinguished very much alike. That gives an opportunity for the functional capabilities to exhibit their slight variations from observation to observation. When the object (or stimulus) difference is of a certain degree, 500 reports in 1000 will be 'different' ('greater' and 'less') and 500 will be 'not-different' ('equal,' 'same,' or 'doubtful'). This difference in stimulus is then said to be *liminal.* In like manner, 50% of 'present' reports (where a given sound is very weak) and 50% of 'non-present' ('silence' or 'doubtful') is again liminal. The first *limen* or *threshold* is the *difference limen* (DL); the second is the *stimulus limen* (RL). The organic variations which give rise to these unevennesses of inspection are known as causes of *accidental 'error.'* Where we speak of 'errors' we must understand that we use a mathematical term. The observer does not 'err' in a psychological or moral sense.

It is not allowable, of course, for the psychologist merely *to assume* from the high variability of the observations that the reports are distributed according to the formulas for chance. The experimenter first discovers how his reports of greater, equal, and less actually run in a given case and then he looks around for some mathematical formula or process which will fit the uniformity discovered. Urban has emphasized this factual basis of the *P*-methods in his doctrine of *psychometric functions.* These functions are the mathematical expressions for the exact way in which a given form of report (*e.g.*, greater or less) changes in relative amount as a stimulus-difference gradually increases or

decreases. Thus a gradual increase of a difference of stimulus is followed by a gradual increase of the number of 'greater' reports. The one increase is a function of the other. Urban speaks of this fact as the 'probability of a given judgment.' The formula which he finds best to fit his facts (lifted weights) is the phi-function of gamma, written $\varphi(\gamma)$. Gamma is a product of a given variate (δ), measured along the line of abscissas and a value (h) representing accuracy or precision. The expression reads $\gamma = h\delta$. *Cf.* F. M. Urban, *Psychol. Rev.*, 17, 1910, 243 ff. For a simpler exposition of the psychometric functions, *cf.* E. G. Boring, *Amer. J. Psychol.*, 28, 1917, 465 ff.; 31, 1920, 1 ff. For a criticism of Urban's use of the hypothesis, *cf.* G. H. Thomson, *Brit. J. Psychol.*, 5, 1912, 203 ff.; *Biometrika*, 12, 1919, 216 ff.

It is assumed that these accidental deviations from the average are due to a large number of elemental factors or causes which combine in every possible way according to hazard. 'The law of error,' which provides a means for estimating the probability of certain combinations of these elemental and unknown factors, declares that (1) the frequency of a given deviation depends upon its magnitude, the smaller deviations occurring more often than the larger, (2) all deviations will tend to fall within a continuously graded series, and (3) in a long series of observations the *plus* and the *minus* deviations will tend to occur with the same frequency.

These assumptions have been carried over to the measurement of the limit of the simpler exercises of function. The facts bear out the assumption that the simple observation of 'presence' or of 'difference' is commonly made under the play of factors akin to the inherent 'errors of observation' in the physical sciences. However constant we keep our stimulus, then, and the other external conditions (the physical light or sound source, *e.g.*, and the general physical surroundings), the report will change in a definable way from moment to moment and from observation to observation.

In view of the wide current use of other quantitative methods in related problems of zoölogy, genetics, education, and the study of the abnormal, it may be well to insist that the spirit and the

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In view of the wide current use of other quantitative methods in related problems of zoölogy, genetics, education, and the study of the abnormal, it may be well to insist that the spirit and the

principles of the *P*-methods restrict their proper application to conditions under which certain refinements may be preserved. As we shall presently see, the loss of these refinements profoundly changes—so far as psychology is concerned—the character and the significance of quantitative procedure.

The experimental literature of the last three decades contains a great number of quantitative studies of acquisition, of illusory perception, of work, of attention, etc. Often the *P*-methods have been modified to suit the individual problem; and not infrequently they have been simplified by reducing the statistical treatment. The chief representative values for the measure of limit have been the average or mean and the mean variation. Where the methods have been used in their strict form, the high constancy of certain of the measures obtained suggests that they rest upon the simplest and purest forms of function which any method has been able to isolate in the field of psychology.

In the emotional forms of execution, in true memory and imagination, and in comprehension and thinking, the functional capacities have scarcely been touched by the stricter methodical procedures of the quantitative kind. Although these functional performances are, for the greater part, fairly complex, it is altogether likely that further wide extensions to our scientific knowledge of the psychological limits of the organism will be added by the same methodical means.

[84] It has been discovered by actual testing that many of the distributions of accomplishment under the tests approximate, when the results are taken in relatively large numbers, the normal type of distribution, which has also been exemplified in death-rate, disease, and stature, and in various problems of economics and public finance. They represent distribution according to chance or probability; and they assume that the individual measures of the group are determined, in part, by a large number of small and independently variable factors combined in every possible way, just as in the 'error' methods of psychophysics. The normal type of distribution is represented by Gauss' law of error.

If the relationship between the phenomena to be correlated is direct, invariable, and perfect (as the relation between rise in

temperature and increase in length of a metal rod), the numerical expression (coefficient) is + 1.00; if negative, invariable, and perfect, then − 1.00, and if no relation obtains, so that the appearance of the one phenomenon is wholly independent of the appearance of the other, correlation is absent and it is expressed by the coefficient 0.0. In many of the problems investigated by the statistical processes used in psychotechnics, some positive relation obtains (coefficients between 0.0 and ± 1.00, and the probability that this connection is present is expressed in terms of correlation with a coefficient standing between + 1.00 and − 1.00.

As it is important to know how closely successive series of *P*-results from a single trained observer are correlated and how much they vary under fatigue or practice, so in the tests it is obviously more satisfactory to discover that one performance, *e.g.*, the naming of logical opposites, is correlated with sentence completion, with the *A*-crossing test, and with adding, to the extents of 0.85 and 0.58 and 0.70 (respectively), than to speak vaguely of a type-complex as 'attentive-and-persistent,' 'erudite,' or 'stable,' which somehow affects the degree of accomplishment in all these directions. But these coefficients bear no specific significance unless the conditions under which they were derived are known and controlled.

An elaborate methodology has grown up under the inventive suggestions of Pearson, Yule, Spearman, Thomson, and others. It is important to note that correlations represent probability only, that they are applicable only to fairly large numbers, and that they are not—at least not usually—to be taken as predictive for a single individual. As regards accomplishment, the degree of correlation indicates only the chances that the degree of one proficiency (as measured by deviation from the central tendency in one performance) will be associated with a certain other proficiency (as measured in a similar way). It no more predicts concomitant proficiencies in the individual than the tables of mortality, upon which the life-insurance companies base their premiums, can prophesy that a given individual of forty-five years will live to the age of sixty-seven.

Thus when Whipple, comparing the strength of the right-hand

and the left-hand squeezing grips of 50 boys came out with the coefficient + 0.92, and an extremely small probable error, he showed that—at least for his group—a strong right-hand grip was very likely to be associated with a correspondingly strong left-hand grip, a weak with a weak, and so on. (G. M. Whipple, *Mental and Physical Measurements,* 1, 1914, 16.) When we take the boys individually, however, we find a wide range of likeness and difference in the strength of the two hands. Thus one boy (Number 25) falls 14 points short of the average squeeze for the entire group (283) when he uses his right hand; but with his left hand he exceeds the average left-hand squeeze (273) by 35 points. This wide difference puts him in 38th place (among the 50 boys) with the one hand, but in 23d place with the other hand. (Possibly he was a left-handed boy who played about his father's blacksmithy.) Of course, since the degree of right-left correlation is very high (r=0.92) and the right and left grips are about equal, it seems to follow that many of the other 49 boys must have exhibited a much higher ambidextrous balance.

Correlation is, then, a "tendency toward concomitant variation," and the coefficient of correlation is the measure of that tendency displayed in a mass or group. If we directly apply the measure of it to the individual person or trait, then we shall have to derive two or more whole sets of results from that person or trait and apply statistical procedures, as in the *P*-methods. Generally, however, the coefficients given in the test-studies are to be interpreted as tendencies toward concomitant variation within an entire group.

[85] *Comparison of the P-methods and the T-methods.* We have observed that the same mathematical foundations underlie the two kinds of quantitative method proposed for measuring the limits of the psychological functions. Both the *P*- and the *T*-methods are based upon the 'law of error' and other similar uniformities of distribution in large numbers. Both propose to measure magnitudes and to state their results in the form of probability. The *P*-methods derive their comparable measures from a large number of trials made under like conditions by a single trained and instructed observer; the *T*-methods from sam-

ples taken either from groups (as in the American Army tests) or from a single individual, who is given a variety of different tasks (as in the original Binet). In the tests, the individual submits, without special training, to a task under which he is admonished to do his best. 'His best' may be wholly undefined or it may be defined in terms of amount, economy of time, or accuracy. The means to be employed are grossly indicated by the setting of the task (the observation of pictures, the marking of pied letters, the 'thinking up' of logical opposites, and so on); but there is no specification of functions to be exercised and no control of the various ways in which a facile organism may reach a given end.

Of the refinements essential to the *P*-methods only the statistical is present in the test. So far as administration is concerned, the test is similar, in principle, to the ordinary school and civil examination. In the treatment of the results, however, the test usually goes beyond the immediate accomplishment of the task to infer its diagnostic significance. Since the test is made under conditions which are not to be found in the scientific experiment, the crudeness of the score has to be relieved by statistical devices. This is doubtless the reason why recent years of testing have brought a large number of mathematical refinements and 'corrections,' which are depended upon to make the results reliable and significant. But it becomes more and more obvious that the results reflect quite as much the conditions of the occasion upon which the test is taken as the assumed ability or efficiency which the subject brings to his task. These *occasional conditions* are of a wide variety. They include the exact manner in which the test-material is laid before the examinee, the manner and the appearance of the examiner, the general organic state and the specific neural trends with which the subject meets his problem, his previous experience with similar tasks, his facility with the pen, emotional bias, the inclination to do well, the motives which tend toward, or away from, high accomplishment, the degree to which the subject comprehends what he is to do, and his aptitude for immediate absorption. All of the variable factors of the occasion, as well as the alternative resources with which the human

worker generally approaches a set task, lie—at least as a rule—outside that 'ability' or those 'abilities' which the test is assumed to measure. Binet's method of surrounding the citadel of 'intelligence' and shelling it from every side may, by its very complexity, cancel certain of those factors against themselves; but it scarcely raises the exercise to the level of an experiment, in the meaning of the sciences.

Whether statistical devices can be made to remedy the defects of the original collection of quantitative materials has not yet been shown. It is important, however, to remember that the final results of the *P*-methods and the *T*-methods are used for quite different purposes; and it may well be that the technological purposes of the administrator of the test will be best served by the means at hand. Unless we insist upon applying psychological criteria to the tests, it will be a misvaluation to judge them by the standards of the other methods. To prove the excellence of the pruning shears and the meat cleaver by a comparison with the instruments of the histologist and the surgeon would be, as Aristotle long ago intimated, to lose sight of the suitability of means as determined by their appropriate ends. In spite of their common mathematical basis, the two types of method have until now occupied different fields.

It is possible that the careful and controlled reports of trained observers, made on the level of accuracy of the psychophysical methods and carried out under the guidance of some such schematic outline of the functions as we have found to be warranted by our present knowledge, might improve our information upon the fundamental modes of organic performance. Such an extended search would certainly—if the last quarter-century in the laboratories is significant—have to take into account the facts of *instruction* and of *task*. If the *T*-methods should, by their mathematical deductions, throw light in the future upon the nature of 'intelligence' or of 'personality,' that light will find enough darkness to dispel. It looks at present, however, as if their inclinations elsewhere would make them more useful in other directions. Whether high correlations run with like functions or with like tasks or like trends, it is at present impossible to say. It is to be

hoped that we shall presently be able to pass beyond vague guesses about cerebral metabolism, synaptic resistance, reservoirs of energy, inherited capacity, and the like, to more empirical and systematic knowledge of the bodily resources as well as of the limits of the psychological functions.

For the problems and methodology of the tests consult G. M. Whipple, *Manual of Mental and Physical Tests,* Baltimore, 1914-15; for the Binet type of tests of intelligence, *cf.* L. M. Terman, *The Measurement of Intelligence, etc.,* New York, 1916. The following books may be used for the description of the tests at large, for underlying theory, and for application: H. E. Garrett, *Statistics in Psychology and Education,* New York, 1926; H. E. Garrett and M. R. Schneck, *Psychological Tests, Methods, and Results,* New York, 1933; G. H. Hildreth, *A Bibliography of Mental Tests and Rating Scales,* New York, 1933; and A. F. Bronner, W. Healy, G. M. Lowe, and M. E. Shimberg, *A Manual of Individual Mental Tests and Testing,* Boston, 1927.

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